PROG20

Perform "R02BOTH"

DBPTC = ADB

Set bit 8(CSMUPDAT) of FLAGWRD1 = 0

Set bit 15(V50N18FL) of FLAGWRD3 = 1 (already 1 from "ISITPOO")

Set bit 5(TRACKFLG) of FLAGWRD1 = 1

OPTION2 = 0

Option 0: LM /"VECPOINT"
1: Celes.Body/"VECPOINT"
2: Rotation
4: LM/ 3 axis
5: Celes.Body/ 3 axis

If bit 7(AUTOSEQ) of FLGWRD10 = 0:

TS = 00024_8

Proceed to "GOPERF4": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to previous line

If (bits 2-1 of OPTION2) $\neq 00_2$: (e.g. options 1, 2, or 5)

Proceed to "DOV6N78"

UTPIT = $K_{35degang}$ (constant is -35^o) (Tag here "PRELOD78")

UTYAW = 0

AZIMANGL = 0

If bit 7(AUTOSEQ) of FLGWRD10 = 1:

Proceed to "P20OPT"

Proceed to "DOV6N78"

DOV6N78

TS = 0678_{vn}

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

TS = 0679_{vn}

Perform "VNFLASHR": (if terminate, proceed to "GOTOPOOH")
if proceed, skip next 3 lines
otherwise, proceed to previous line

If bit 2 of OPTION2 = 0: (e.g. options 0, 1, 4, or 5)

TS = 101_2 and perform "BLANKET" (R3BLNK and R1BLNK)

End of job

If bit 3 of OPTION2 = 1: (e.g. option 4 or 5) (Tag here "ENDV6N79")

Set bit 8(AZIMFLAG) of FLGWRD11 = 1

Proceed to second line of "P20OPT"

Proceed to "P20OPT"

<u>P20OPT</u>

Set bit 8(AZIMFLAG) of FLGWRD11 = 0

If (bits 2-1 of OPTION2) = 00_2: (e.g. option 0 or 4)

Set bit 9(UTFLAG) of FLAGWRD8 = 0

Set bit 7(UPDATFLG) of FLAGWRD1 = 1

Proceed to "NDUTINPT"

OPTNTYPE = (bits 2-1 of OPTION2) - 1 (Tag here "UTKINPUT")

Set bit 9(UTFLAG) of FLAGWRD8 = 1

Set bit 7(RNDVZFLG) of FLAGWRD0 = 0

If OPTNTYPE > 0: (e.g. option 2)

TS = 0634_{vn} (Tag here "TYPE2IN")

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

R67TIME = DSPTEM1

Proceed to "NDUTINPT"

Proceed to "V1N70DSP" (e.g. option 1 or 5)

V1N70DSP

TS = 0170_{vn}

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

If STARCODE < 0: (contrary to e.g. "R51DSPA", -0, i.e. 77777_8, is not rejected)

Set bit 7(Operator Error) of channel 11 = 1

Proceed to "V1N70DSP"

If STARCODE > 50_8:

Set bit 7(Operator Error) of channel 11 = 1

Proceed to "V1N70DSP"

UTSTARNO= STARCODE

If STARCODE > 0:

Proceed to "NDUTINPT"

If STARCODE = +0: (if -0, no display)

TS = 0688_{vn}

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

PLANVCUT = STARSAV3

Proceed to "NDUTINPT"

NDUTINPT

Set restart group 2 to cause a start at next line (priority 26_8 to PHSPRDT2)

If bit 9(UTFLAG) of FLAGWRD8 = 1:

Establish "STATINT1"(priority 05_8) (Tag here "INTSETUP")

Set restart group 2 to phase 5(i.e. 2.5, causing "STATINT1" to be established with priority 05_8 if a restart)

Set restart group 1 to phase 11(i.e. 1.11, causing "PIKUP20" to be established with priority 10_8 if a restart)

Proceed to "PIKUP20"

MARKTIME = T_{now} (communication cell with "SETINTG")

Perform "SETINTG"

If bit 8(CSMUPDAT) of FLAGWRD1 = 1:

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Perform "INTEGRV"

Set restart group 2 to start at next line

Perform "SETINTG"

If bit 1(RENDWFLG) of FLAGWRD5 = 1:

Set bit 1(WMATINT) of FLAGWRD3 = 1

If bit 8(CSMUPDAT) of FLAGWRD1 = 0:

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Perform "INTEGRV"

Set bit 7(RNDVZFLG) of FLAGWRD0 = 1

Establish "R22" (priority 26_8)

Set restart group 2 to phase 7 (i.e. 2.7, causing "R22" to be established with priority 10_8 if a restart)

Set restart group 1 to phase 11 (i.e. 1.11, causing "PIKUP20" to be established with priority 10_8 if a restart)

Perform "AUTOCHK" (returns immediately if bit 7(AUTOSEQ) of FLGWRD10 is zero)

Proceed to "PIKUP20"

PIKUP20 (Entered from "NDUTINPT" and due to restart group 1.11)

Change priority of present job to 14_8

If bit 5(TRACKFLG) of FLAGWRD1 = 0:

Proceed to "FIXDB"

If bit 13(REFSMFLG) of FLAGWRD3 = 0:

Proceed to "FIXDB"

R61CNTR = 0

If bit 9(UTFLAG) of FLAGWRD8 = 1:

Proceed to "CALLR6X"

Set bit 14(R21MARK) of FLAGWRD2 = 1

Perform "R61CSM"

If bit 15(PCMANFLG) of FLGWRD10 = 1: (set e.g. by "P79" and "P86")

Proceed to third line of "AUTOCHK"

Proceed to "P20TRACK"

P20TRACK (Entered from "PIKUP20" and "P79A")

Set bit 10(LMTRG) of FLAGWRD1 = 1

Perform "R52"

Perform "MKRELEAS"

Proceed to "FIXDB"

PROG21

OPTION2 = 1

Set bit 5(TRACKFLG) of FLAGWRD1 = 1

TS = 00002_8

Proceed to "GOPERF4": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to previous line

DSPTEM1 = 0

Proceed to "P21PROG1"

P21PROG1

TS = 0634_{vn}

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

TS = DSPTEM1

If TS = 0:

TS = T_{now}

Proceed to "P21PROG2"

P21PROG2

T_{decl} = TS

Perform "INTSTALL"

If bit 12(P21FLAG) of FLAGWRD2 = 0: (set 0 e.g. in "INITSUB")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

If $|OPTION2| \geq 2$:

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Set bits 4(CONICINT) and 1(WMATINT) of FLAGWRD3 = 0

Perform "INTEGRV"

If bit 12(P21FLAG) of FLAGWRD2 = 1:

$RC\underline{V}$ = $P21BASE\underline{R}$ (tag here "P21CONT")

$VC\underline{V}$ = $P21BASE\underline{V}$

T_{et} = P21TIME

Set bit 1(WMATINT) of FLAGWRD3 = 0 (Note that bit 4 <u>not</u> set.)

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

If P21ORIG $\neq$ 0:

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

Perform "INTEGRVS"

P21TIME = T_{att} (tag here "P21VSAVE")

$P21BASE\underline{R}$ = $\underline{R}_{att1}$ (B29 earth, B27 moon)

$P21BASE\underline{V}$ = $\underline{V}_{att1}$ (B7 earth, B5 moon)

If bit 10(NEWTFLAG) of FLAGWRD5 = 1: (i.e. from P29)

Set bit 10(NEWTFLAG) of FLAGWRD5 = 0

Proceed to "HOP29DSP"

If bit 1(P29FLAG) of FLAGWRD0 = 1:

Proceed to "LONGPASS"

TS = $|P21BASE\underline{V}|$ (B7 earth, B5 moon)

Shift TS right X2 places (make B7; X2 set from integration)

P21VEL = TS

P21GAM = $\sin^{-1}\left((\text{unit}\underline{R}_{att} \cdot \underline{V}_{att}) / \text{P21VEL}\right)$

P21ORIG = X2

Set bit 12(P21FLAG) of FLAGWRD2 = 1

Set bit 12(LUNLATLO) of FLAGWRD3 = 0 (Tag here "P21DSP")

If X2 $\neq$ 0: (e.g. 2, meaning moon)

Set bit 12(LUNLATLO) of FLAGWRD3 = 1

ALPHA$\underline{V}$ = $\underline{R}_{att}$

Set bit 13(ERADCOMP) of FLAGWRD1 = 0

TS = T_{att}

Perform "LAT-LONG"

P21ALT = K_{kp01} ALT

TS = 0643_{vn}

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to "GOTOPOOH"
otherwise, proceed

DSPTEM1_{dp} = P21TIME + K_{600sec}

Proceed to "P21PROG1"

PROG22

Perform "R02BOTH"

If bit 9(UTFLAG) of FLAGWRD8 = 1:

Set bit 5(TRACKFLG) of FLAGWRD1 = 1

Set bit 7(RNDVZFLG) of FLAGWRD0 = 0

$T_{decl} = T_{now}$

Perform "CSMCONIC"

pMGA = $\cos^{-1}\left(\left|\text{unit}(\underline{V}_{att} * \underline{R}_{att}) \cdot \text{REFSMMAT}_{3}\right|\right)$

$TS = 0645_{vn}$

Perform "VNFLASHR": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed to "PROG22A"
otherwise, proceed to previous line

$TS = 011_2$ and perform "BLANKET" (R2BLNK, R1BLNK)

End of job

PROG22A

Set bits 12-10 of LANDMARK = 0 (second octal digit)

Set bit 9(LMKTRG) of FLAGWRD1 = 1

Set bit 8(CSMUPDAT) of FLAGWRD1 = 1

Set bit 12(LUNLATLO) of FLAGWRD3 = 0

Set bit 11(P22MKFLG) of FLAGWRD3 = 0

Set bit 13(ERADCOMP) of FLAGWRD1 = 1

If bit 12(CMOONFLG) of FLAGWRD8 = 0: (earth-centered)

Perform "P22SUBRB"

Perform "R52"

Proceed to "DOV5N71"

Set bit 12(LUNLATLO) of FLAGWRD3 = 1

$(TS_1, TS_2) = (0570_{vn}, 1307_8)$

Perform "S22N7071"

Perform "R52"

Proceed to "DOV5N71"

DOV5N71

$(TS_1, TS_2) = (0571_{vn}, 0)$

Perform "S22N7071"

Set bit 11(P22MKFLG) of FLAGWRD3 = 1

NUM8KK = 1

S22LOC = "SVMRKDAT"

Proceed to "S22.1"

P22SUBRB (Entered from "PROG22A", "PROG24", "P23N7071", and "S22N7071")

$TS = 0689_{vn}$

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

If $(\frac{1}{4} - |LAT|) < 0$: (LAT input magnitude exceeded 90^o)

Set bit 7(Operator error) of channel 11 = 1

Proceed to "P22SUBRB"

If $(\frac{1}{4} - |LANDLONG|) < 0$: ($\frac{1}{2}$ longitude input magnitude exceeded 90^o)

Set bit 7(Operator error) of channel 11 = 1

Proceed to "P22SUBRB"

LONG = 2 LANDLONG

ALT = LANDALT

Return

S22N7071 (Entered with TS_1 set to verb-noun pattern)

$NUM8KK = TS_1$

$NUM8KK+1 = TS_2$ (used as flag: non-zero for N70, zero for N71)

TS = NUM8KK (0570_{vn} for pre-mark, lunar only; 0571_{vn} after marks)

Perform "VNFLASHR": (if terminate, proceed to "GOTOPOOH")
if proceed, skip next 2 lines
otherwise, proceed to previous line

$TS = 101_2$ and perform "BLANKET" (R3BLNK and R1BLNK)

End of job

CXOFF = (bits 12-10 of LANDMARK), shifted right 9 places (digit B)

If $(CXOFF - 5) > 0$:

Set bit 7(Operator error) of channel 11 = 1

Proceed to 3rd line of "S22N7071"

Set bit 8(LNDKNOWN) of FLAGWRD6 = 0

TS = (bits 15-13 of LANDMARK) (digit A)

If TS = 0:

Set bit 7(Operator error) of channel 11 = 1

Proceed to 3rd line of "S22N7071"

If TS $\geq$ 3:

Set bit 7(Operator error) of channel 11 = 1

Proceed to 3rd line of "S22N7071"

If TS = 1:

Set bit 8(LNDKNOWN) of FLAGWRD6 = 1

22SUBSCL = (bits 6-1 of LANDMARK) (digits DE)

If 22SUBSCL - 1 > 0:

If NUM8KK+1 = 0: (displaying N71)

Set bit 7(Operator error) of channel 11 = 1

Proceed to 3rd line of "S22N7071"

If (bits 6-4 of 22SUBSCL) $\neq$ 5: (digit D)

Set bit 7(Operator error) of channel 11 = 1

Proceed to 3rd line of "S22N7071"

Set bit 10(ADVTRK) of FLAGWRD8 = 1 (Tag here "DE-GR-50")

Perform "R52" starting at second line

Proceed to "DOV5N71"

If bit 8(LNDKNOWN) of FLAGWRD6 = 0: (Tag here "S22ABDE")

Return

If 22SUBSCL = 0:

Perform "P22SUBRB"

Return

$TS_2 = T_{now}$ (tag here "S22LSITE")

$\underline{TS}_1 = RL\underline{S}$

TS = $\frac{1}{2}$ (non-zero, meaning moon)

Perform "RP-TO-R"

ALPHA$\underline{V}$ = T$\underline{S}$, shifted right 2 places (B29)

TS = T_{now}

Perform "LAT-LONG"

Return

S22.1 (Entered from "DOV5N71" to process P22 mark data)

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

S22EORM = 0 (earth-centered)

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

S22EORM = -2 (moon-centered)

Perform "SETINTG" (T_{decl} written over before being used)

If bit 6(ORBWFLAG) of FLAGWRD3 = 1:

Set bit 1(WMATINT) of FLAGWRD3 = 1

If bit 6(ORBWFLAG) of FLAGWRD3 = 0:

Set bit 1(RENDWFLG) of FLAGWRD5 = 0

$W_i = 0$ (i = 0 - 17) (i.e. $[W_0]$ and $[W_1]$)

$W_i = 0$ (i = 27 - 44) (i.e. $[W_3]$ and $[W_4]$)

W_i = WORBPOS (i = 0, 4, 8, diagonal elements of $[W_0]$)

W_i = WORBVEL (i = 36, 40, 44, diagonal elements of $[W_4]$)

$W_i = 0$ (i = 18 - 26) (i.e. $[W_2]$) (Tag here "SETVANDI")

$W_i = 0$ (i = 45 - 80) (i.e. $[W_5]$ through $[W_8]$)

Set bit 9(DMENFLG) of FLAGWRD5 = 0 (means 6x6)

Proceed to "S22NXTIN"

S22NXTIN

$T_{decl} = E_{S22LOC_{dp}}$ (i.e. time of mark)

Perform "INTEGRV"

$\text{CSMPO}\underline{\text{S}} = \text{RC}\underline{\text{V}}_{cm}$ + $(\text{DELTA}\underline{\text{V}}_{cm}$ shifted right 7 - S22EORM places)

X1 = - S22LOC

Perform "GETUM"

$\text{U}\underline{\text{M}} = \text{T}\underline{\text{S}}$

If NUM8KK = CXOFF: (mark is offset one)

    $\text{S22TOFF} = \text{E}_{\text{S22LOC}_{dp}}$ (i.e. time of mark) (Tag here "S22OFF=I")

    $\text{S22UOF}\underline{\text{F}} = \text{U}\underline{\text{M}}$

    Proceed to "S22I=N"

If bit 9(DMENFLG) of FLAGWRD5 = 1: (i.e. first non-offset mark processed)

    $\text{T}\underline{\text{S}}_1 = \text{X78}\underline{9}$ (Tag here is "S22D=9")

    TS_2 = S22TPRIM (time of last mark, i.e. time tag of $\text{X78}\underline{9}$)

    TS = S22EORM (0 for earth, non-zero for moon)

    Perform "R-TO-RP"

    $\text{T}\underline{\text{S}}_1 = \text{T}\underline{\text{S}}$

    $\text{TS}_2 = \text{E}_{\text{S22LOC}_{dp}}$ (time of present mark)

    TS = S22EORM

    Perform "RP-TO-R"

    $\text{X78}\underline{9} = \text{T}\underline{\text{S}}$

    Proceed to "S22BOX32"

Set bit 6(ORBWFLAG) of FLAGWRD3 = 1

Set bit 9(DMENFLG) of FLAGWRD5 = 1

Set bit 13(22DSPFLG) of FLAGWRD2 = 1

If bit 8(LNDKNOWN) of FLAGWRD6 = 1:

    $W_i = C_{s22wsubl}$ (i = 72, 76, 80, diagonal $[W_8]$) (Tag here "S22BOX22")

    $\text{TS} = \text{E}_{\text{S22LOC}_{dp}}$ (i.e. time of mark)

    Perform "LALOTORV"

(If bit 8(LNDKNOWN) of FLAGWRD6 = 1):

$\underline{TS} = ALPHA\underline{V}$

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift $T\underline{S}$ left 2 places (to B27)

$X78\underline{9} = T\underline{S}$

Proceed to "S22BOX32"

$ALPHA\underline{V} = unitCSMPO\underline{S}$

Perform "SETRE"

$TS = - unitCSMPO\underline{S} \cdot U\underline{M}$

$TS_1 = ERADM$

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift TS_1 left 2 places (to scale factor B27)

$$S22RHO = |CSMPO\underline{S}| \left(TS - \sqrt{(TS_1/|CSMPO\underline{S}|)^2 - (1 - TS^2)} \right)$$

$X78\underline{9} = CSMPO\underline{S} + S22RHO\ U\underline{M}$

$T\underline{S} = X78\underline{9}$

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift $T\underline{S}$ right 2 places (to B29)

$S22R\underline{L} = T\underline{S}$

$S22D = S22R\underline{L} \cdot U\underline{M}$

$PDMXI_i = 0 \quad (i = 0 - 8)$

$PDMXI_i = 1 \quad (i = 2, 4, 6)$

$S22UMR\underline{L}_0 = UM_x\ S22R\underline{L}$

$S22UMR\underline{L}_3 = UM_y\ S22R\underline{L}$

$S22UMR\underline{L}_6 = UM_z\ S22R\underline{L}$

$S22UMR\underline{L}_0 = PDMX\underline{I}_6 - (S22UMR\underline{L}_0) / S22D$ (Tag here is "S22NXTU")

$S22UMR\underline{L}_3 = PDMX\underline{I}_3 - (S22UMR\underline{L}_3) / S22D$

$S22UMR\underline{L}_6 = PDMX\underline{I}_0 - (S22UMR\underline{L}_6) / S22D$

$$[S22UMRL] = \begin{bmatrix} S22UMR\underline{L}_0 \\ S22UMR\underline{L}_3 \\ S22UMR\underline{L}_6 \end{bmatrix}$$

$\underline{W}_{54+3i} = [S22UMRL] \ \underline{W}_{3i}$ (i = 0 - 5, loading $[W_6]$ and $[W_7]$ from modified $[W_0]$ and $[W_1]$)

TS = S22RHO

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift TS right 2 places (to B30)

$S22RHO = \frac{1}{2} K_{sctvar} \ TS^2$

$S22UU\underline{T}_0 = S22RHO \ [S22UMRL] \ S22UMR\underline{L}_0$

$S22UU\underline{T}_3 = S22RHO \ [S22UMRL] \ S22UMR\underline{L}_3$

$S22UU\underline{T}_6 = S22RHO \ [S22UMRL] \ S22UMR\underline{L}_6$

$S22UMR\underline{L}_0 = UM_x \ U\underline{M}$

$S22UMR\underline{L}_3 = UM_y \ U\underline{M}$

$S22UMR\underline{L}_6 = UM_z \ U\underline{M}$

$S22RHO = C_{rpvar} \ (ERADM / S22D)^2$

$S22UU\underline{T}_0 = S22UU\underline{T}_0 + S22RHO \ S22UMR\underline{L}_0$ (Tag here "S22NXXB")

$S22UU\underline{T}_3 = S22UU\underline{T}_3 + S22RHO \ S22UMR\underline{L}_3$

$S22UU\underline{T}_6 = S22UU\underline{T}_6 + S22RHO \ S22UMR\underline{L}_6$

Reset overflow indicator

$TS = S22UUT_8$

If $TS \geq 0$:

$TS = \sqrt{TS}$

If $TS \neq 0$:

$W_{74} = TS$ (rescaled to B19)

$TS_1 = S22UUT_7 / W_{74}$

If overflow has not taken place since indicator reset:

$W_{73} = TS_1$ (rescaled to B19)

Reset overflow indicator

(If $TS \neq 0$):

$TS_2 = S22UUT_6 \ / \ W_{74}$

If overflow has not taken place since indicator reset:

$W_{72} = TS_2$ (rescaled to B19)

Reset overflow indicator

$TS = S22UUT_4 - W_{73}^2$ (Tag here is "S22W76X")

If $TS \geq 0$:

$TS = \sqrt{TS}$

If $TS \neq 0$:

$W_{76} = TS$ (rescaled to B19)

$TS_1 = (S22UUT_3 - W_{72} W_{73}) \ / \ W_{76}$

If overflow has not taken place since indicator reset:

$W_{75} = TS_1$ (rescaled to B19)

$TS = S22UUT_0 - (W_{75}^2 + W_{72}^2)$ (Tag here "S22W78X")

If $TS \geq 0$:

$W_{78} = \sqrt{TS}$ (rescaled to B19)

$S22TPRIM = E_{S22LOC_{dp}}$ (i.e. time of mark)

Proceed to "S22I=N"

S22BOX32

Set bit 11(FSTINCRP) of FLAGWRD5 = 1

Reset overflow indicator

$RCL\underline{P} = X78\underline{9} - CSMPO\underline{S}$

$T\underline{S} = unitRCL\underline{P} * U\underline{M}$

$T\underline{S}_1 = unitT\underline{S}$

If overflow has taken place (e.g. all components of $T\underline{S} < 2^{-19}$ rad) since overflow indicator reset:

$S22TPRIM = E_{S22LOC_{dp}}$

Proceed to "S22I=N"

$USTAR\underline{R} = T\underline{S}_1$

Proceed to "S22BOX12"

S22BOX12

$TS = (K_{sctvar} + K_{imuvarr}) \ (|RCL\underline{P}|)^2$

Shift TS right by 2 (- S22EORM) places (to B40)

VARIANCE = TS

Perform "BVECTORS"

$BVECTO\underline{R}_2 = - BVECTO\underline{R}_0$

Perform "INCORP1"

If bit 13(22DSPFLG) of FLAGWRD2 = 1:

Set bit 13(22DSPFLG) of FLAGWRD2 = 0

$N49DISP = |DELTA\underline{X}_0|$, shifted right -S22EORM places (B29)

$N49DISP+2 = |DELTA\underline{X}_1|$, shifted right -S22EORM places (B7)

$TS = 0649_{vn}$

Perform "GOFLASHR": if terminate, proceed to "GOTOPOOH"
if proceed, skip next 2 lines
otherwise, proceed to "PROG22A"

$TS = 100_2$ and perform "BLANKET" (R3BLNK)

End of job

Perform "INCORP2" (Tag here is "S22BOX42")

$CSMPO\underline{S} = RC\underline{V}_{cm} + (DELTA\underline{V}_{cm}$ shifted right 7 - S22EORM places)

If bit 11(FSTINCRP) of FLAGWRD5 = 1:

Set bit 11(FSTINCRP) of FLAGWRD5 = 0

$RCL\underline{P} = X78\underline{9} - CSMPO\underline{S}$

Proceed to "S22BOX12"

$S22TPRIM = E_{S22LOC_{dp}}$ (i.e. time of mark)

Proceed to "S22I=N"

S22I=N

If (NUM8NN - NUM8KK) > 0:

NUM8KK = NUM8KK + 1

S22LOC = S22LOC + 7

Perform "SETINTG" (T_{decl} written over before being used)

If bit 9(DMENFLG) of FLAGWRD5 = 1: (i.e. first mark not an offset one)

Set bit 1(WMATINT) of FLAGWRD3 = 1

Set bit 2(9DIMWMAT) of FLAGWRD3 = 1

Proceed to "S22NXTIN"

If bit 6(ORBWFLAG) of FLAGWRD3 = 1: (Tag here "S22D6Z")

Set bit 1(WMATINT) of FLAGWRD3 = 1

Proceed to "S22NXTIN"

If CXOFF = 0: (all marks processed if get here, tag "S22F244X")

S22TOFF = $E_{S22LOC_{dp}}$ (i.e. time of last mark)

If CXOFF $\neq$ 0:

If NUM8NN - CXOFF < 0:

S22TOFF = $E_{S22LOC_{dp}}$

If NUM8NN - CXOFF $\geq$ 0:

T_{decl} = S22TOFF

Perform "CSMPREC"

CSMPO$\underline{S}$ = $\underline{R}_{attl}$ (B29 earth, B27 moon)

U$\underline{M}$ = S22UOF$\underline{F}$

TS = |X78$\underline{9}$|

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift TS right 2 places (B29)

ERADM = TS

(If NUM8NN - CXOFF $\geq$ 0):

$TS = -\ \text{unitCSMPOS}\underline{S} \cdot U\underline{M}$

$TS_1 = \text{ERADM}$

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift TS_1 left 2 places (to scale factor B27)

$$\text{S22RHO} = \left|\text{CSMPO}\underline{S}\right| \left(TS - \sqrt{(TS_1 / \left|\text{CSMPO}\underline{S}\right|)^2 - (1 - TS^2)} \right)$$

$\text{X78}\underline{9} = \text{CSMPO}\underline{S} + \text{S22RHO}\ \ U\underline{M}$

$T\underline{S} = \text{X78}\underline{9}$ (Tag here "S22BX44A")

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift $T\underline{S}$ right 2 places (B29)

$\text{ALPHA}\underline{V} = T\underline{S}$

TS = S22TOFF

Perform "LAT-LONG"

LANDLONG = $\frac{1}{2}$ LONG

LANDALT = ALT

$TS = 0689_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "S22GTP"
if proceed, proceed to "S22.981X"
otherwise, proceed

TS_2 = S22TOFF

$T\underline{S}_1 = \text{X78}\underline{9}$

TS = $\frac{1}{2}$ (i.e. non-zero, meaning moon)

Perform "R-TO-RP"

$RL\underline{S} = T\underline{S}$

Proceed to "S22.981X"

S22.981X

Perform "9DWTO6DW"

Proceed to "PROG22A"

S22GTP

Perform "9DWTO6DW"

Proceed to "GOTOPOOH"

PROG24

("R61CSM" and "R63" now in ATTM section)

PASSCNT = C_{nopass}

Perform "R02BOTH"

If bit 9(UTFLAG) of FLAGWRD8 = 1:

Set bit 5(TRACKFLG) of FLAGWRD1 = 1

Set bit 3(P24MKFLG) of FLAGWRD2 = 0

Set bit 14(NEWLMFLG) of FLAGWRD8 = 0

Set bit 6(ORBWFLAG) of FLAGWRD3 = 0

Set bit 1(RENDWFLG) of FLAGWRD5 = 0

Set bit 14(P24FLAG) of FLAGWRD9 = 1

SVMRKDAT+i = 0 (i = 0 - 35) (Tag here "ZERODNIK")

Set bit 11(P22MKFLG) of FLAGWRD3 = 0

Set bit 7(RNDVZFLG) of FLAGWRD0 = 0

MARKTIME = T_{now} (communication cell with "SETINTG")

Perform "SETINTG"

Perform "INTEGRV"

Set bit 13(ERADCOMP) of FLAGWRD1 = 1

Set bit 12(LUNLATLO) of FLAGWRD3 = 0

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Set bit 12(LUNLATLO) of FLAGWRD3 = 1

Perform "P22SUBRB"

Set bit 9(LMKTRG) of FLAGWRD1 = 1

Perform "R52"

Proceed to "GOTOPOOH"

P29

Set bit 1(P29FLAG) of FLAGWRD0 = 1

Proceed to "PROG21" ("P21PROG2" exits to "LONGPASS" since P29FLAG is set)

LONGPASS

$TS = 0643_{vn}$

Perform "VNFLASHR": (if terminate, proceed to "GOTOPOOH")
if proceed, skip next 2 lines
otherwise, proceed to previous line

$TS = 101_2$ and perform "BLANKET" (R3BLNK, R1BLNK)

End of job

LONGFOR = LONG (LONG contents destroyed)

Proceed to "HOP29DSP"

HOP29DSP

$T\underline{S}_1$ = unit$\underline{Z}$

TS_2 = P21TIME (tag also P29BASET)

PASSTIME = TS_2

Set bit 1(P29FLAG) of FLAGWRD0 = 1

DELTLONG = 0

TS = 0

Set bit 12(LUNLATLO) of FLAGWRD3 = 0

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Set bit 12(LUNLATLO) of FLAGWRD3 = 1

$TS = K_{fmoon}$ (i.e. non-zero, meaning moon)

Perform "RP-TO-R" (leaves T$\underline{S}$ with Z polar vector)

MUSUB$\underline{E}$ = unit(T$\underline{S}$ * P21BASE$\underline{R}$) (P21BASE$\underline{R}$ tag also P29BASE$\underline{R}$)

MUSUB$\underline{C}$ = unit(T$\underline{S}$ * MUSUB$\underline{E}$)

$\underline{TS}_1$ = unit(P21BASE$\underline{R}$ * P21BASE$\underline{V}$) (P21BASE$\underline{V}$ tag also P29BASE$\underline{V}$)

MUSUB$\underline{S}$ = unit($\underline{TS}_1$ * P21BASE$\underline{R}$)

MUSUB$\underline{N}$ = $\underline{TS}_1$ sgn($\underline{TS}_1$ · T$\underline{S}$) (T$\underline{S}$ from "RP-TO-R")

T$\underline{S}$ = P21BASE$\underline{R}$

Proceed to "HOPALONG"

HOPALONG

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift T$\underline{S}$ right 2 places (to B29)

ALPHA$\underline{V}$ = T$\underline{S}$

TS = PASSTIME

Set bit 13(ERADCOMP) of FLAGWRD1 = 0

Perform "LAT-LONG"

LNGERR = (LONGFOR - LONG), modulo 1 revolution

TS_1 = |LNGERR| - $K_{epsilong}$

If $TS_1 < 0$:

Proceed to "PASSOUT"

TS_2 = TS_1 + $K_{twiceeps}$

If $TS_2 \geq 1$: (the 1 is revolutions)

Proceed to "PASSOUT"

If bit 1(P29FLAG) of FLAGWRD0 = 0: (i.e. not first iteration)

If (TS_2 - $\frac{1}{2}$) $\geq$ 0: (Tag here "MODULO")

LNGERR = (TS_2 - $\frac{1}{2}$ - $K_{epsilong}$ - $\frac{1}{2}$) sgn LNGERR

(same as LNGERR - 1 sgn LNGERR)

If bit 1(P29FLAG) of FLAGWRD0 = 1: (first iteration)

Set bit 1(P29FLAG) of FLAGWRD0 = 0

If LNGERR < 0:

LNGERR = LNGERR + $(1 - 2^{-28})$

(If bit 1(P29FLAG) of FLAGWRD0 = 1):

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

LNGERR = LNGERR - $(1 - 2^{-28})$

FUDGE = K_{fmoon}

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

FUDGE = K_{fearth} (Tag here "HOP1")

Reset overflow indicator (Tag here "THETCOMP")

TS = FUDGE LNGERR + DELTLONG

If overflow has taken place: (i.e. $|TS| \geqslant 1$ rev)

TS = P21TIME + K_{600sec} (Tag here "ADDTEN")

Set bit 10(NEWTFLAG) of FLAGWRD5 = 1

Proceed to "P21PROG2" (exits to "HOP29DSP")

DELTLONG = TS

$MUSUB\underline{D} = \text{unit}\left((MUSUB\underline{E} \cos DELTLONG + MUSUB\underline{C} \sin DELTLONG) * MUSUB\underline{N} \right)$

$ORBDLT = \left(\cos^{-1} (\text{unit}P21BASE\underline{R} \cdot MUSUB\underline{D}) \right) \text{sgn} (MUSUB\underline{D} \cdot MUSUB\underline{S})$

SNTH = sin ORBDLT

X1 = -2

CSTH = cos ORBDLT

RVE$\underline{C}$ = P21BASE$\underline{R}$

VVE$\underline{C}$ = P21BASE$\underline{V}$

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

X1 = -10

Set bit 9(RVSW) of FLAGWRD7 = 0 (new $\underline{R}$, $\underline{V}$ desired)

Perform "TIMETHET"

PASSTIME = T + P21TIME

$T\underline{S} = T\underline{S}_r$ (value from "TIMETHET")

Proceed to "HOPALONG"

PASSOUT

DSPTEM1 = PASSTIME

$TS = 0634_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to "LONGPASS"

$TS = 0643_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to "P29"

Proceed to "GOTOPOOH"

Quantities in Computations

See also list of major variables and list of routines

22SUBSCL: Single precision cell, scale factor B14, loaded with bits 6-1 of LANDMARK in "S22N7071". A value of 00 means that an N89 input is to be specified, while a value of 01 means that the RLS site is selected. Prior to taking marks (i.e. the N70 display as contrasted with the N71 display), values of 50_8 - 57_8 are used to select the advanced ground track mode for use in R52 (where the least significant digit of LANDMARK is employed to determine the number of orbits desired).

ADB: See Digital Autopilot Interface Routines.

ALPHAV: See Coordinate Transformations.

ALT: See Coordinate Transformations.

AZIMANGL: Value of "rotation angle" used in options 4 and 5 (3-axis) of P20, scale factor B0, units revolutions. It is loaded via R3 of N78, and is also modified in "STARTAUT" when a minimum key rendezvous sequence is started. Cell has no effect unless bit 8(AZIMFLAG) of FLGWRD11 = 1; a "heads up" value is 0^o and a "heads down" 180^o.

BVECTOR$_1$: See Measurement Incorporation.

C_{nopass}: See Optics Computations.

C_{rpvar}: Erasable memory (double precision) constant, program notation "RPVAR", scale factor B28, units meters^2, giving the "variance of the primary body radius vector."

$C_{s22wsubl}$: Single precision erasable memory constant, program notation "S22WSUBL", scale factor B19, units meters, giving the initial conditions for diagonal elements of $[W_8]$ for known landmark.

CSMPOS: See Measurement Incorporation.

CSTH: See Conic Routines.

CXOFF: Single precision cell, scale factor B14, giving the value for bits 12-10 of LANDMARK (shifted right 9 places), which is the offset designator.

DBPTC: Single precision value of deadband used for P20 maneuvers, scale factor B-1, units revolutions. It is loaded into ADB in "R61CSM" and "R67START" (unless a value of zero is indicated, in which case the 0.5^o deadband is used). It is initialized to the current ADB at the start of "PROG20" and can be loaded via R2 of N79.

DELTA$\underline{V}_{cm}$: See Orbital Integration.

$DELTAX_{-1}$: See Measurement Incorporation.

DELTLONG: Change in longitude computed in P29 from the time that "HOPALONG" was initiated, scale factor B0, units revolutions. It is the change from the vector reflected in e.g. P21BASE$\underline{R}$.

ERADM: See Coordinate Transformations.

FUDGE: Factor used to convert LNGERR information to DELTLONG, scale factor B1. It approximates the ratio of the number of revolutions of the spacecraft with respect to inertial space to the number with respect to a fixed longitude in equal time periods.

$K_{35degang}$: Constant, program notation "35DEGANG", scale factor B0, units revolutions. Value is -0.097222222222, corresponding to -35^{o}. Used in "PROG20" to initialize UTPIT for rendezvous options.

K_{600sec}: Constant, program notation "600SEC", scale factor B28, units centi-seconds. Value is 60000 x 2^{-28}, corresponding to 600 seconds or 10 minutes.

$K_{epsilong}$: Constant, program notation "EPSILONG", scale factor B0, units revolutions. Value is 0.2777778E-4, corresponding to 0.01^{o} (the P29 convergence criterion).

K_{fearth}: Constant, program notation "FEARTH", scale factor B1, used to load FUDGE in P29 for earth orbit. Value is 1.06666667 x 2^{-1}, where first term is nominal value (i.e. 16/15) and second is scale factor. Corresponds roughly to proper FUDGE value for an earth-orbiting spacecraft with a period of 90 minutes (16 revs per 24 hours).

K_{fmoon}: Constant, program notation "FMOON", scale factor B1, used to load FUDGE in P29 for lunar orbit. Value is 0.996958637 x 2^{-1}, where first term is nominal value (i.e. 327.8/328.8) and second is scale factor. Corresponds roughly to proper FUDGE value for a lunar-orbiting spacecraft with a period of 2 hours.

$K_{imuvarr}$: Constant, program notation "IMUVARR", scale factor B-18, units radians^2. Value is 0.04E-6 x 2^{18}, corresponding to 0.04 mr^2 (the same decimal value, but different scaling, as K_{imuvar} in Measurement Incorporation).

K_{kp01}: Constant, program notation "K.01", scale factor B0, value 0.01. Used to convert output from "LAT-LONG" from units of meters to units of meters/100, so that the DSKY display scale, usually XXXX.X nmi, will be XXXXXb. nmi instead for P21ALT.

K_{sctvar}: Constant, program notation "SCTVAR", scale factor B-18, units radians^2. Value is 1.0E-6 x 2^{-18}, corresponding to 1.0 mr^2.

$K_{twiceeps}$: Constant, program notation "TWICEEPS", scale factor B0, units revolutions. Value is 0.5555556E-4, corresponding to 0.02°, or twice the value of $K_{epsilong}$.

LANDALT: Cell used by N89 to display altitude information, scale factor B29, units meters. The scaling from normal XXXX.X to XXX.XX nmi is handled for N89 by the noun table information.

LANDLONG: Cell used by N89 to display longitude information, scale factor B0, units of two revolutions (hence if treated as if in units of revolutions, display would be of ½ the true angle).

LANDMARK: Single precision cell which is displayed in R2 by N70 and N71. Considering the five octal digits displayed to be ABCDE, the following code is assigned:

A: Used in P22 to indicate known landmark if 1, unknown if 2 (other values not allowed).

B: Used in P22 to load CXOFF (offset mark serial number). Digit set 0 at start of "PROG22A", and can be set to the serial number of the mark just made by V52E. If loaded manually, values in excess of five are rejected, and in excess of NUM8NN cause no processing in "S22I=N".

C: Used in P23 to indicate earth of 1, lunar if 2 (other values not allowed). If LANDMARK = 0, P23 requires a horizon measurement.

DE: Landmark identification. Value ignored by P23 (except for impact on zero/non-zero nature of LANDMARK cell).
In P22, used to indicate that an N89 input is required if 00, and that $RL\underline{S}$ should be used if 01. For the N71 display, these are the only two values allowed. For the N71 display, values in the range 50_8 - 57_8 are also allowed, specifying 0-7 advanced orbits for R52.

LAT: See Coordinate Transformations.

LNGERR: Value of longitude error in P29, scale factor B0, units revolutions. Stored in push-down list location 0D.

LONG: See Coordinate Transformations.

LONGFOR: Value of desired longitude (entered into R2 of N43) in P29, scale factor B0, units revolutions.

MARKTIME: See Measurement Incorporation.

$MUSUB\underline{C}$: Unit vector, scale factor B1, perpendicular to polar vector and $MUSUB\underline{E}$, used in P29.

$MUSUB\underline{D}$: Unit vector, scale factor B1, used in P29 iteration to compute ORBDLT. Stored in push-down list locations 0D and 6D.

MUSUBE: Unit vector, scale factor B1, in easterly direction, used in P29.

MUSUBN: Unit vector, scale factor B1, in plane defined by angular momentum (and same hemisphere as north polar axis), used in P29.

MUSUBS: Unit vector, scale factor B1, in direction of tangential velocity for P29 computations.

N49DISP, N49DISP+2: See Measurement Incorporation.

NUM8KK: Single precision cell, program notation "8KK", scale factor B14, containing the serial number of the mark being processed in P22. It is initialized to 1 in "DOV5N71", and incremented in "S22I=N". Cell also used for temporary storage in "S22N7071" of verb/noun pattern. The following cell is used in the same routine as a control flag (zero means N71, and non-zero, i.e. 1307_8 = 711, means N70: the octal is 0571_{vn}).

NUM8NN: Single precision cell, program notation "8NN", scale factor B14. Initialized to zero in "SXTMARK" for P22 and P24, and incremented for marks (decremented P22 mark rejects) in the optics processing logic. Mark processing in "S22I=N" is halted when NUM8NN equals NUM8KK.

OPTION2: See Display Interface Routines.

OPTNTYPE: Single precision cell, scale factor B14, used to retain information on the P20 option selected: it is set equal to (bits 2-1 of OPTION2) - 1, hence zero for selection of option 1/5(celestial body) and 1 for selection of option #2 (rotation). Not loaded for option 0/4 (rendezvous).

ORBDLT: Required angle change (converted via "TIMETHET" to a time and a new position vector) in the P29 loop, scale factor B0, units revolutions. Stored in push-down list location 0D.

P21ALT: Value of K_{kp01} ALT computed in "P21PROG2" for (optional) display in R1 of N73, scale factor B29, units (meters/100): see K_{kp01}.

P21BASER: Value of P21/P29 "base" vector for position (notation also P29BASER), scale factor B29 (earth) or B27 (moon), units meters. The earth/moon scaling determined for P21 by P21ORIG (P29 computations not intended for use except in orbit, hence use CSM state vector flag instead). In P21, loaded after completion of integration to specified input time, and used to initialize the integration if bit 12(P21FLAG) of FLAGWRD2 = 1, thus permitting computation time to be saved if it is desired to iterate about a point which is a number of orbital integration time steps removed from the "permanent" CSM/LM state vector.

P21BASEV: Value of P21/P29 "base" vector for velocity (notation also P29BASEV), scale factor B7(earth) or B5(moon), units meters/centi-second. See P21BASER.

P21GAM: Value of flight path angle computed in "P21PROG2" for (optional) display in R3 of N73 in P21, scale factor B0, units revolutions.

P21ORIG: Single precision value for "origin" information for P21 base vector (not used by P29), scale factor B14. A value of 0 means earth, and a value of 2 means moon.

P21TIME: Cell used to retain time information (notation also P29BASET), scale factor B28, units centi-seconds. Used to contain the time tag of P21BASE$\underline{R}$ and P21BASE$\underline{V}$, and to permit the incrementing of the time associated with the N34 display.

P21VEL: Value of velocity computed in "P21PROG2" for (optional) display in R2 of N73 in P21, scale factor B7, units meters/centi-second.

PASSCNT: See Optics Computations.

PASSTIME: Time associated with current iteration in P29 loop, scale factor B28, units centi-seconds. When convergence criterion is satisfied, information in this cell is loaded in DSPTEM1 for N34 display.

[PDMX$\underline{I}$] : Identity matrix stored in push-down list, scale factor of elements B3. With respect to the conventional sequence, for convenience in using the push-down list, PDMX$\underline{I}_6$ has unit$\underline{X}$; PDMX$\underline{I}_3$ has unit$\underline{Y}$, and PDMX$\underline{I}_0$ has unit$\underline{Z}$. Stored in push-down list location 0D.

PLANVCU$\underline{T}$: Value of STARSAV$\underline{3}$ (N88) information sampled in "V1N70DSP" for use in options 1 or 5 of P20 (display generated if N70 = +0). Can be with arbitrary (but consistent) scaling.

pMGA: See Display Computations.

R61CNTR: Single precision cell, scale factor B14, used for control of "R61CSM", and as a flag (if negative) that this routine has called R60 (requiring DSKY priority displays for the performance of the maneuver). Positive values cause the cell to be decremented and performance of the remainder of the routine to be bypassed; the setting to 3 causes the routine to be performed every fourth time it is entered, assuming that R61CNTR is not set 0 by the calling routine.

R67TIME: Value of the time at which maneuver is to be started for option 2 of P20, loaded in "P20OPT" from N34 information, scale factor B28, units centi-seconds. Used in "CALLR6X" to determine when "R67" should be called, for OPTNTYPE > 0 (i.e. option 2).

RCL$\underline{P}$: See Measurement Incorporation.

RC$\underline{V}$, RC$\underline{V}_{cm}$: See Orbital Integration.

RL$\underline{S}$: See Coordinate Transformations.

RVE$\underline{C}$: See Conic Routines.

S22D: Value of S22R$\underline{L}$ · U$\underline{M}$, scale factor B29, units meters, stored in push-down list location 30D.

S22EORM: Single precision cell, scale factor B14, used as a shift and control cell in P22 (loaded at start of "S22.1" with 0 for earth-centered computations and -2 for moon-centered computations).

S22LOC: Single precision cell used to retain information on the address of the mark data for processing in P22. It is initialized to the address of SVMRKDAT in "DOV5N71", and incremented by 7 in "S22I=N".

S22RHO: Cell used for temporary storage purposes in P22 (and P24 when computing a revised landmark location), corresponding to push-down list location 32D. When used to multiply U$\underline{M}$, scale factor is B30 (earth) or B28 (moon). When used to compute initial values for [S22UUT], scale factor is partially contained in X2 (if X2 = 0, scale factor B42); for second term of [S22UUT], scale factor B34.

S22R$\underline{L}$: Value of landmark vector in P22 rescaled to scale factor B29, units meters (same scaling for earth and moon).

S22TOFF: Value of time tag (i.e. time of measurement) for the offset optics mark in P22, scale factor B28, units centi-seconds, loaded in "S22NXTIN" if NUM8KK = CXOFF. In P24, or if no offset mark was specified in P22, used to contain time tag of mark for use in converting X78$\underline{9}$ to latitude/longitude/altitude information for possible display and, for P22, RL$\underline{S}$ loading.

S22TPRIM: Value of time of last mark processed in P22, scale factor B28, units centi-seconds, for use in "S22NXTIN" to update the value of X78$\underline{9}$ to the time of the next mark.

[S22UMRL]: Value of matrix quantities used in P22 for initialization of [W_6] and [W_7], initially with scale factor B30 and then, after computation involving division by S22D, with scale factor B3. Also used for computation of information for [W_8], where has scale factor B2.

S22UOF$\underline{F}$: Value of U$\underline{M}$ (measurement vector) for the offset optics mark in P22, scale factor B1 (see S22TOFF).

[S22UUT]: Value of matrix quantities used in P22 for initialization of [W_8], scale factor B36. S22UUT$_i$, with i = 0, 3, 4, 6, 7, and 8, corresponds to what may appear elsewhere as e_j (j = 0 - 5 respectively).

SNTH: See Conic Routines.

STARCODE: See Inflight Alignment.

STARSAV$\underline{3}$: See Inflight Alignment.

SVMRKDAT: Set of buffer cells used to telemeter mark information in P22 and P24. Up to 5 sets of mark data may be handled, each of which has the double precision value of mark time, followed by CDU_y, optics shaft, CDU_z, optics trunnion, and CDU_x. In P24, cells initialized to zero before optics marks initiated. In both P22 and P24, time tags are complemented to indicate a mark rejection. P24 loads the cells cyclically as marks are obtained (P22 has a limit of 5 marks, filling the buffer). The initialization is to a binary zero, meaning a "scaled value" for trunnion information of -19.7754°, as might be seen on some displays.

T: See Conic Routines.

T_{et}: See Orbital Integration.

$U\underline{M}$: See Measurement Incorporation.

UTPIT: Value of "pitch angle" used in P20, scale factor B0, units revolutions. It is loaded via R2 of N78, with a value of -35° the normal rendezvous initialization (preferred tracking axis) value.

UTYAW: Value of "yaw angle" used in P20, scale factor B0, units revolutions. It is loaded via R1 of N78, with a value of zero the normal rendezvous initialization: zeros for UTPIT and UTYAW correspond to +X axis tracking.

$USTA\underline{R}$: See Measurement Incorporation.

UTSTARNO: Value of STARCODE information sampled in "V1N70DSP" for use in options 1 or 5 of P20. Scale factor B14.

VARIANCE: See Measurement Incorporation.

$VC\underline{V}$: See Orbital Integration.

$VVE\underline{C}$: See Conic Routines.

$\left[W_i\right]$, W_i, $\underline{W}_i$: See Measurement Incorporation.

WORBPOS, WORBVEL: See Measurement Incorporation.

$X78\underline{9}$: See Measurement Incorporation.

GTSCPSS Entered via V37 E 01 E

If bit 12(NODOPO1) of FLAGWRD1 = 1:

Proceed to "POODOO" (pattern 21521_8)

Change priority of present job to 20_8 (was established at 13_8)

GEOCOMP1 = 1 (Logic checking this cell not shown)

1dPIPADT = K_{1dppgt}

LENGTHOT = K_{bt8}

1SECXT1 = K_{1d2scx}

PREMTRXC = 1

$PERFDLAY_{dp}$ = 1 (centi-second)

NEWAZMTH = LAUNCHAZ

OLDAZMTH = LAUNCHAZ

Perform "POSN17C"

Perform "IMUZERO" (Tag here is "GEOIMUTT")

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

NDXCTR = 0

$\underline{X}_{dc} = (1, 0, 0)$

$\underline{Y}_{dc} = (0, \sin C_{azmth}, \cos C_{azmth})$

$\underline{Z}_{dc} = (0, -\cos C_{azmth}, \sin C_{azmth})$

Perform "CALCGA" (comes here if MODREG $\neq$ 3, since should still be 1 at this point)

Perform "IMUCOARS"

If bit 14(GLOKFAIL) of FLAGWRD3 = 1:

NDXCTR = NDXCTR + 1

Set bit 14(GLOKFAIL) of FLAGWRD3 = 0

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

If NDXCTR $>$ 0:

Proceed to "PIPACHK" (a check of PIPA's)

Perform "IMUFINE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

Call "GOESTIMS" in $PERFDLAY_{dp}$ centi-seconds (set to 1 above)

Put present job to sleep (starting address id = "ESTIMS")

GOESTIMS

Awaken job with starting address id = "ESTIMS"

End of task

SOMERR2

Perform "ALARM" (pattern 1601_8)

Set bit 8(IMUSE) of FLAGWRDO = 0 (tag here is "ENDTEST1")

TS = -0 and perform "NEWMODEX" (blanks program register)

Perform "MKRELEAS"

Proceed to "ENDEXT"

POSN17C

$\underline{X}_{sm}$ = (0, - cos NEWAZMTH, sin NEWAZMTH)

$\underline{Y}_{sm}$ = (0, sin NEWAZMTH, cos NEWAZMTH)

$\underline{Z}_{sm}$ = (-1, 0, 0)

Return

ESTIMS Entered from awakened job via "GOESTIMS", or from end of "ALFLT" for azimuth change

Inhibit interrupts

GTSWTLT1 = TIME1

PIP$\underline{A}$ = 0

Release interrupts

$INTVEC1_y$ = 0

$INTVEC1_z$ = 0

$FILDELV1_y$ = 0

$FILDELV1_z = 0$

$THETA\underline{N} = 0$

GCOMPSW = 0

$GCOM\underline{P} = 0$

$DEL\underline{V} = 0$

$ERVECTO\underline{R} = K_{omegms}(\sin C_{atd}, -\cos C_{atd}, 0)$

$T_{mark} = T_{now}$

$ERCOM\underline{P} = 0$

ERECTIME = LENGTHOT

TS = 02 and perform "NEWMODEX"

Perform "PIPUSE"

LENGTHOT = 9

Proceed to "SLEEPIE"

<u>SLEEPIE</u>

Perform "CHKCOMED"

Perform "SETGWLST"

End of job

<u>CHKCOMED</u>

Inhibit interrupts

If MODREG = 7:

Return

If bit 5(Liftoff complement) of channel 30 = 1:

If bit 5(BKUPLO) of FLAGWRD5 = 0: (set 1 by "LFTFLGON" for a V75E)

Release interrupts

Return

Set priority of present job to 22_8 (was established at that anyhow)

Proceed to "P11"

SETGWLST

Inhibit interrupts

TS = GTSWTLT1 - TIME1

If TS $>$ 0:

TS = TS - 163.83 seconds (should be 163.84)

TS = TS + 1SECXT1

If TS $\leq$ 0:

TS = 0.04 seconds

Call "ALLOOP" in TS seconds

Return (interrupts released e.g. by End of job)

ALLOOP

GTSWTLT1 = TIME1

Set restart group 5 to cause restart at next line

Set $\underline{DELV}_{sp}$ = $\underline{PIPA}$ and $\underline{PIPA}$ = +0 (no special restart provisions)

Set restart group 5 to cause restart at next line

Establish "ALFLT" (priority 22_8)

End of task

ALFLT

Perform "CHKCOMED"

Perform "1/PIPA"

$\underline{TS} = \underline{DELV} \left[X_{sm}\right]$

$DPIPAY = - TS_y$

$DPIPAZ = TS_z$

$FILDELV1_y = FILDELV1_y + K_{geocl} (DPIPAY - FILVELV1_y)$ (Tag here is "ALWAYSG")

$INTVEC1_y = INTVEC1_y + FILDELV1_y$

$FILDELV1_z = FILDELV1_z + K_{geocl} (DPIPAZ - FILDELV1_z)$

$INTVEC1_z = INTVEC1_z + FILDELV1_z$

If ERECTIME $\neq$ 0:

$$THETAN_y = THETAN_y - K_{geoc5} (FILDELV1_z + K_{geoc2} INTVEC1_z)$$

$$THETAN_z = THETAN_z - K_{geoc5} (FILDELV1_y + K_{geoc2} INTVEC1_y)$$

If ERECTIME = 0:

$$THETAN_x = THETAN_x + K_{pipgyr} FILDELV1_y$$

$$THETAN_y = THETAN_y - K_{geoc3} FILDELV1_z - K_{geoc4} INTVEC1_z$$

$$THETAN_z = THETAN_z - K_{geoc3} FILDELV1_y$$

If LENGTHOT > 0:

LENGTHOT = LENGTHOT - 1

Proceed to "SLEEPIE"

Perform "CHKCOMED"

If LGYRO > 0: (gyros torquing, e.g. from "1/PIPA" compensation)

Proceed to "SLEEPIE"

$\underline{ERCOMP} = \underline{ERCOMP} + [X_{sm}] \ \underline{THETAN}$

Note that restart protection from here onward is priority 20_8 (job established at 22_8).

Perform "EARTHR*"

$\underline{THETAN} = 0$

If PREMTRXC > 0: (set 0 by "AZMTHCG1")

ERECTIME = ERECTIME - 1, limited $\geq$ 0

LENGTHOT = 9

Proceed to "SLEEPIE"

TS = LAUNCHAZ - OLDAZMTH

If TS = 0:

PREMTRXC = 1

ERECTIME = ERECTIME - 1, limited $\geq$ 0

LENGTHOT = 9

Proceed to "SLEEPIE"

PREMTRXC = 1

NEWAZMTH = LAUNCHAZ

$ERCOMP_z$ = TS

Perform "POSN17C" (zero elements not reset 0)

OLDAZMTH = NEWAZMTH

LENGTHOT = K_{bt7}

TS = "ERCOMP"

Perform "IMUPULSE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

Proceed to "ESTIMS"

EARTHR*

$TS = T_{now}$

$TS_1 = TS - T_{mark}$

If $TS_1 < 0$:

$TS_1 = TS_1 + 2^{28}$ centi-seconds

$\underline{ERCOMP} = \underline{ERCOMP} + [X_{sm}] \; TS_1 \; \underline{ERVECTOR}$

$T_{mark} = TS$

TS = "ERCOMP"

Perform "IMUPULSE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

Return

AZMTHCG1 Established by "CHAZFOGC" for V78E, with priority 16_8

DSPTEM1 = NEWAZMTH, converted to single precision twos complement, scale factor B-1, units revolutions.

Perform "CLEANDSP"

$TS = 0629_{vn}$

Proceed to "GOFLASH": if terminate, skip next line
if proceed, proceed
otherwise, proceed to previous line

LAUNCHAZ = DSPTEM1, converted to double precision ones complement, scale factor B0, units revolutions

PREMTRXC = 0

Proceed to "PINBRNCH"

<u>GCOMPVER</u> Established by "CKOPTVB" for V65E, with priority 16_8

TS = 03 and perform "NEWMODEX"

$\underline{X}_{dc} = (1, 0, 0)$

$\underline{Y}_{dc} = (0, \sin C_{azmth}, \cos C_{azmth})$

$\underline{Z}_{dc} = (0, -\cos C_{azmth}, \sin C_{azmth})$

Perform "MKRELEAS" (comes here if MODREG = 3, as it should)

Perform the following for i = 1 and then i = 2:

DSPTEM1+2 = i

DSPTEM1+0 = TAZ_i

DSPTEM1+1 = TEL_i

$TS = 0530_{vn}$

Perform "GODSPRET"

$TS = 0641_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GCOMP5"
if proceed, proceed
otherwise, proceed to 3rd previous line

TAZ_i = DSPTEM1+0

TEL_i = DSPTEM1+1

STARCODE = 1

$TS = 0$

Perform "TARGDRVE"

$\underline{STARAD} = \left[X_{sm}\right] (\sin TEL_1, -\cos TAZ_1 \cos TEL_1, \sin TAZ_1 \cos TEL_1)$

$\underline{STARBD} = \left[X_{sm}\right] (\sin TEL_2, -\cos TAZ_2 \cos TEL_2, \sin TAZ_2 \cos TEL_2)$

X1 = - "MRKBUF1"

$\underline{CDUSPOT} = \underline{E}_{2-X1}$

Perform "SXTNB"

Perform "TRG*NBSM"

$\underline{LOSVEC} = \underline{TS}$

STARCODE = 2 (Tag here "NEXBNKSS")

$TS = 6$

Perform "TARGDRVE"

X1 = - "MRKBUF1"

$\underline{CDUSPOT} = \underline{E}_{2-X1}$

Perform "SXTNB"

Perform "TRG*NBSM"

$\underline{STARBC} = \underline{TS}$

$\underline{STARAC} = \underline{LOSVEC}$

Perform "AXISGEN"

Perform "CALCGTA"

$TS = 0693_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GCOMP5"
if proceed, proceed
otherwise, proceed to previous line

$\underline{ERCOMP} = \underline{ERCOMP} + \underline{OGC}$

Proceed to "GCOMP5"

GCOMP5

TS = 02 and perform "NEWMODEX"

End of job

TARGDRVE

If TS = 0:

$\underline{STAR} = (\sin TEL_1, - \cos TAZ_1 \cos TEL_1, \sin TAZ_1 \cos TEL_1)$

If TS = 6:

$\underline{STAR} = (\sin TEL_2, - \cos TAZ_2 \cos TEL_2, \sin TAZ_2 \cos TEL_2)$

Perform "SXTANG"

DESOPTS = SAC_{sp}

DESOPTT = PAC_{sp}

Proceed to "RETARG"

RETARG

OPTIND = +0

Perform "SXTMARK"

If MARKINDX > 0: (no mark obtained)

Proceed to "RETARG"

Perform "MKRELEAS"

Return (to routine calling "TARGDRVE")

Quantities in Computations

See also list of major variables and list of routines

1dPIPADT: See IMU Computations.

1SECXT1: Single precision quantity, scale factor B14, units centi-seconds, giving required period of computations for "ALLOOP". Set to 0.5 seconds for gyro compassing.

C_{atd}: Erasable memory (double precision) constant, program notation "LATITUDE", scale factor B0, units revolutions. It gives the "local vertical astronomical latitude" of the pad.

C_{azmth}: Erasable memory (double precision) constant, program notation "AZIMUTH", scale factor B0, units revolutions. It gives the "azimuth of the vehicle Z-axis east of north."

CDUSPOT: See Coordinate Transformations.

DESOPTS, DESOPTT: See Optics Computations.

DPIPAi (i = Y,Z): Value of accelerometer output modified for use in gyrocompassing. The y axis of this system is south and the z axis is east (from $[X_{sm}]$). Scale factor of DPIPAi is B14, units accelerometer counts.

ERCOMP: Value of gyro compensation to be sent to gyros, scale factor B21, units pulses (or scale factor B0, units revolutions, since one pulse is 2^{-21} revolution). Program notation also "ERCOMP1".

ERECTIME: Single precision length of time to be spent in erection phase, scale factor B14, units of five-second gyro compassing cycles. It is set to LENGTHOT in "ESTIMS". Program notation also "ERECTIM1".

ERVECTOR: Earth rotation vector initialized in "ESTIMS", scale factor B1, units gyro pulses/centi-second.

$FILDELV1_{y,z}$: Filtered velocity in the y and z directions, scale factor B14, units accelerometer counts. Here "y" is north.

GCOMP, GCOMPSW: See IMU Computations.

GEOCOMP1: Single precision cell set positive non-zero to indicate that gyro-compassing computations are being performed. The logic that checks this cell is <u>not</u> shown in this writeup. See Testing Routines.

GTSWTLT1: Single precision cell, scale factor B14, units centi-seconds, giving the value of TIME1 when "ALLOOP" last entered, and used to construct proper waitlist value for the next call in "SETGWLST".

$INTVEC1_{y,z}$: Summed values of $FILDELV1_y$ and $FILDELV1_z$ respectively, scale factor B14, units accelerometer counts.

K_{1d2scx}: Single precision constant, program notation "1/2SECX", scale factor B14, units centi-seconds. Value is 50×2^{-14}, corresponding to 0.5 second.

K_{1dppgt}: Single precision constant, program notation "1/PIPAGT", scale factor B8, units centi-seconds. Value is 06200_8, corresponding to 0.5 seconds.

K_{bt7}: Single precision constant, program notation "BIT7", scale factor B14, units of five-second gyro compassing cycles. Octal value is 00100_8, corresponding to decimal 64, used to load LENGTHOT, and thence ERECTIME, for a change in input azimuth: value gives $64 \times 5 =$ 320 seconds for vertical erection.

K_{bt8}: Single precision constant, program notation "BIT8", scale factor B14, units of five-second gyro compassing cycles. Octal value is 00200_8, corresponding to decimal 128, used to load LENGTHOT, and thence ERECTIME, at start of P01 (in "GTSCPSS"): value gives $128 \times 5 =$ 640 seconds for vertical erection at start of P02.

K_{geoc1}: Constant, program notation "GEOCONS1", scale factor B0, value 0.1.

K_{geoc2}: Constant, program notation "GEOCONS2", scale factor B0, value 0.005.

K_{geoc3}: Constant, program notation "GEOCONS3", scale factor B7, units gyro pulses/accelerometer pulse. Value is 0.062, corresponding to a "true" value of 7.936.

K_{geoc4}: Constant, program notation "GEOCONS4", scale factor B7, units gyro pulses/accelerometer pulse. Value is 0.0003, corresponding to a "true" value of 0.0384.

K_{geoc5}: Constant, program notation "GEOCONS5", scale factor B7, units gyro pulses/accelerometer pulse. Value is 0.5, corresponding to a "true" value of 64.

K_{omegms}: Constant, program notation "OMEG/MS", scale factor B0, units gyro pulses/centi-second. Value is 0.24339048, corresponding approximately to $(1/86164.0932) \times 10^{-2} \times 2^{21}$, where first term is earth rotation period in seconds (used to derive constant), second converts to centi-seconds, and third is number of gyro torquing pulses in one revolution.

K_{pipgyr}: Dummy constant used to indicate change in units between accelerometer pulses and gyro torquing pulses, scale factor B7. Value is 1.00, corresponding to 2^7 or 128.

LAUNCHAZ: Value of desired launch azimuth, scale factor B0, units revolutions. Since is used at the start of P01, should form part of prelaunch erasable load, although it can also be updated in "AZMTHCG1" (via V78E). Program notation also "LUNCHAZ1".

LENGTHOT: Single precision cell, scale factor B14, loaded in "GTSCPSS" with K_{bt8} (for loading into ERECTIME) and at the end of "ALFLT", if a new azimuth specification received, with K_{bt7}. It is also used as a counter of the number of half-seconds that have elapsed since the previous entrance to "EARTHR*", to control the nominal gyro compassing cycle of five seconds (via an initial setting to 9 and a 1SECXT1 setting to 0.5 seconds).

LGYRO: See IMU Computations.

LOSVEC: Unit vector, scale factor B1, serving in "GCOMPVER" as a temporary storage cell for the sighting vector to the first target.

MARKINDX, MRKBUF1: See Optics Computations.

NDXCTR: Single precision cell, scale factor B14, used in "GTSCPSS" to retain information on bit 14(GLOKFAIL) of FLAGWRD3, which should be 0 if do P01.

NEWAZMTH: Communication cell with "POSN17C", scale factor B0, units revolutions, used to compute the required orientation of the stable member. Program notation also "NEWAZ1". Set to LAUNCHAZ in "GTSCPSS" and "ALFLT" (if an input azimuth change).

OGC: See Coordinate Transformations.

OLDAZMTH: Value of azimuth angle presently reflected in computations, scale factor B0, units revolutions. If, with PREMTRXC = 0, LAUNCHAZ = OLDAZMTH, it is concluded that no input change took place, and no re-initialization (via entrance to "ESTIMS") of gyro compassing is done. OLDAZMTH is set as described for NEWAZMTH, but at a slightly different time for restart considerations.

OPTIND: See Optics Computations.

PAC: See Coordinate Transformations.

PERFDLAY: Communication cell with routine calling "GOESTIMS", set to one centi-second at start of "GTSCPSS", scale factor B28, units centi-seconds (the "LONGCALL" entrance to the waitlist system is used).

PIPA: See IMU Computations.

PREMTRXC: Single precision cell, scale factor B14, initialized to 1 in "GTSCPSS" and set 0 at the end of "AZMTHCG1". If sensed as 0 in "ALFLT"(when LENGTHOT has run down), then, if LAUNCHAZ $\neq$ OLDAZMTH, gyro compassing is re-initialized. In any event, PREMTRXC is reset to 1. Program notation also "PREMTRX1".

SAC: See Coordinate Transformations.

STAR: See Coordinate Transformations.

STARAC, STARAD, STARBC, STARBD: See Coordinate Transformations.

STARCODE: See Inflight Alignment (setting in "GCOMPVER" is not functional, since the cell is not displayed by the mark routine).

T_{mark}: Value of time when previous earth-rate compensation was made, scale factor B28, units centi-seconds.

TAZ_1, TAZ_2, TEL_1, TEL_2: Single precision erasable memory cells (which could be set as part of erasable memory load) giving azimuth (TAZ_i) and elevation(TEL_i) for targets #1 and #2 used in P03. For azimuth information, scale factor is B-1 in twos complement; for elevation, scale factor is B-2: in both cases, units are revolutions.

THETAN: Value of required number of gyro torquing pulses (before rotation by $[X_{sm}]$, and hence in the vertical, south, east system), scale factor B21, units pulses. Program notation also "THETAN1".

Rendezvous Computations

PRECSET

$T_{dec2} = T_{dec1}$

Perform "LEMCONIC"

If bit 5(LMACTFLG) of FLAGWRD2 = 0:

$\underline{R}_{pass3} = \underline{R}_{att}$

$\underline{V}_{pass3} = \underline{V}_{att}$

If bit 5(LMACTFLG) of FLAGWRD2 = 1:

$\underline{R}_{act3} = \underline{R}_{att}$

$\underline{V}_{act3} = \underline{V}_{att}$

$T_{dec1} = T_{dec2}$

Perform "CSMCONIC"

If bit 5(LMACTFLG) of FLAGWRD2 = 0:

$\underline{R}_{act3} = \underline{R}_{att}$

$\underline{V}_{act3} = \underline{V}_{att}$

If bit 5(LMACTFLG) of FLAGWRD2 = 1:

$\underline{R}_{pass3} = \underline{R}_{att}$

$\underline{V}_{pass3} = \underline{V}_{att}$

$UP\underline{1} = unit(unit\underline{R}_{pass3} * \underline{V}_{pass3})$

$CMYDOT = \underline{V}_{act3} \cdot UP\underline{1}$

$AUTOY = \underline{R}_{act3} \cdot UP\underline{1}$

$UNR\underline{M} = unit(\underline{R}_{act3} * \underline{V}_{act3})$

$LMYDOT = \underline{V}_{pass3} \cdot UNR\underline{M}$

Return

S33/34.1

Entered from "P33/P73B" and "P34/P74C"

TITER = -16383

$SECMAX = K_{max250}$

$\underline{R}_{aprec} = \underline{R}_{act3}$

$\underline{V}_{aprec} = \underline{V}_{act3}$

$\underline{R}_{pprec} = \underline{R}_{pass3}$

$\underline{V}_{pprec} = \underline{V}_{pass3}$

Proceed to "ELCALC"

ELCALC

$ULO\underline{S} = \text{unit}(\underline{R}_{pass3} - \underline{R}_{act3})$

$UNR\underline{M} = \text{unit}(\underline{R}_{act3} * \underline{V}_{act3})$

$U\underline{P} = \text{unit}\left(ULO\underline{S} - (ULO\underline{S} \cdot \text{unit}\underline{R}_{act3})\ \text{unit}\underline{R}_{act3}\right)$

$TS_1 = (UNR\underline{M} * \underline{R}_{act3}) \cdot U\underline{P}$

$TS = \cos^{-1}\left((U\underline{P} \cdot ULO\underline{S})\ \text{sgn}\ TS_1\right)$ (elevation angle)

If $(ULO\underline{S} \cdot \underline{R}_{act3}) < 0$:

$TS = (1 - 2^{-28}) - TS$

If bit 14(ITSWITCH) of FLAGWRD7 = 0: (Set 1 in "P33/P73B"; set 0 near start of "P34/P74C" if HAVEELEV = 0, and later there if it = 1)

$T_{tpi} = T_{tpi} + NOMTPI$

If bit 7(HAVEELEV) of FLAGWRD2 = 0:

ELEV = TS (TS derived above, elevation angle)

TS = 0 (non-error return flag)

Return (to routine calling "S33/34.1")

DELELO = DELEL

DELEL = TS - ELEV (TS derived above, elevation angle)

If $|DELEL| - K_{eeps} < 0$:

TS = 0 (non-error return flag)

Return (to routine calling "S33/34.1")

$TS = \frac{1}{2}\ TITER$

If $TS_{sp} = 0$:

Return (to routine calling "S33/34.1": $TS \neq 0$, indicating error)

$TITER = TS_{sp}$

$TS = (\frac{1}{2} - ELEV)\ \text{sgn}\ (|\underline{R}_{pass3}| - |\underline{R}_{act3}|)$ (The $\frac{1}{2}$ is 180°)

If $TS < 0$: ($|\underline{R}_{pass3}|$ in 12D; $|\underline{R}_{act3}|$ in 14D; units OD & 6D)

Return (to routine calling "S33/34.1": $TS \neq 0$, indicating error)

$PD28CS = - \left|\underline{R}_{act3}\right| \cos(\frac{1}{2} - ELEV) / \left|\underline{R}_{pass3}\right|$

$TS = 1 - \left|PD28CS\right|$

If $TS < 0$:

Return (to routine calling "S33/34.1": $TS \neq 0$, indicating error)

$PDOMEGA = \left|\underline{R}_{pass3}\right| \left(unit(UNR\underline{M} * unit\underline{R}_{act3})\right) \cdot \underline{V}_{act3}$

$T\underline{S} = unit\underline{R}_{pass3} * \underline{V}_{pass3}$

$PDOMEGP = \left|\underline{R}_{act3}\right| \left(unit(T\underline{S} * unit\underline{R}_{pass3})\right) \cdot \underline{V}_{pass3}$

$TS_1 = \left(unit\underline{R}_{act3} * unit\underline{R}_{pass3}\right) \cdot UNR\underline{M}$

$PDALFMPI = \left(\cos^{-1}(unit\underline{R}_{pass3} \cdot unit\underline{R}_{act3})\right) sgnTS_1 - \frac{1}{2} + ELEV$

$TS_2 = (\frac{1}{2} - \cos^{-1} PD28CS) \; sgn \left(\left|\underline{R}_{pass3}\right| - \left|\underline{R}_{act3}\right|\right)$ ($\frac{1}{2}$ is 180^o)

$$PDDELTM = K_{twopi} \frac{\left|\underline{R}_{act3}\right| \left|\underline{R}_{pass3}\right| (PDALFMPI + TS_2)}{PDOMEGA - PDOMEGP}$$

If $\left|PDDELTM\right| - SECMAX \geq 0$:

$PDDELTM = SECMAX \; sgn \; PDDELTM$

If $TITER < 0$: (i.e. first pass) (Tag here "OKMAX")

$TITER = 37777_8$

DELTEEO = PDDELTM

NOMTPI = NOMTPI + DELTEEO

Proceed to "ADTIME+3"

If (DELEL DELELO) < 0: (i.e. sign change in angle)

SECMAX = SECMAX / 3

$DELTEEO = - \frac{1}{2}\left|PDDELTM\right| \; sgn \; DELTEEO$

NOMTPI = NOMTPI + DELTEEO

Proceed to "ADTIME+3"

If $|\text{DELELO}| - |\text{DELEL}| \geq 0$:

DELTEEO = |PDDELTM| sgn DELTEEO

NOMTPI = NOMTPI + DELTEEO

Proceed to "ADTIME+3"

TS = DELTEEO

DELTEEO = $-\frac{1}{2}$ DELTEEO

NOMTPI = NOMTPI - TS + DELTEEO (same as NOMTPI = NOMTPI $-1.5\ \text{DELTEEO}_{n-1}$)

Proceed to "ADTIME+3"

ADTIME+3

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If NOMTPI $\neq$ 0: (as it would be expected to be)

Set bit 4(CONICINT) of FLAGWRD3 = 1

T_{decl} = NOMTPI

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

$T_{et} = 0$

RC$\underline{V}$ = $\underline{R}_{aprec}$, shifted left X2 places (B29 earth, B27 moon)

VC$\underline{V}$ = $\underline{V}_{aprec}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{act3} = \underline{R}_{att}$

$\underline{V}_{act3} = \underline{V}_{att}$

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If NOMTPI $\neq$ 0:

    Set bit 4(CONICINT) of FLAGWRD3 = 1

T_{decl} = NOMTPI

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

    Set bit 12(MOONFLAG) of FLAGWRD0 = 0

T_{et} = 0

RC$\underline{V}$ = $\underline{R}_{pprec}$, shifted left X2 places (B29 earth, B27 moon)

VC$\underline{V}$ = $\underline{V}_{pprec}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{pass3} = \underline{R}_{att}$

$\underline{V}_{pass3} = \underline{V}_{att}$

Proceed to "ELCALC"

<u>S34/35.2</u> Entered from "HARTBURN", "P34/P74C", and "P35/P75B"

SUBEXIT = Return address

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If $NN1_{sp}$ = 0:

    Set bit 4(CONICINT) of FLAGWRD3 = 1

$T_{decl} = T_{pass4}$

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

    Set bit 12(MOONFLAG) of FLAGWRD0 = 0

T_{et} = INTIME

RC$\underline{V}$ = $\underline{R}_{pass3}$, shifted left X2 places (B29 earth, B27 moon)

VC$\underline{V}$ = $\underline{V}_{pass3}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{targ} = \underline{R}_{att}$

Proceed to "S3435.25"

<u>S3435.25</u>

$\underline{V}_{pass4} = \underline{V}_{att}$

$TS_1 = (unit\underline{R}_{act3} * unit\underline{R}_{targ}) \cdot UNR\underline{M}$

$TS = \left(\cos^{-1} (unit\underline{R}_{act3} \cdot unit\underline{R}_{targ})\right) \text{ sgn } TS_1$

If $TS < 0$:

$TS = TS + (1 - 2^{-28})$

ACTCENT = TS

$DELLT4 = T_{pass4} - INTIME$

$TS_1 = NN1_{sp}$

$TS_2 = K_{epsfour}$

$\underline{R}_{init} = \underline{R}_{act3}$

$\underline{V}_{init} = \underline{V}_{act3}$

Perform "INITVEL"

$T\underline{S}_2 = - UNR\underline{M}$

$T\underline{S}_3 = - unit\underline{R}_{act3}$

$T\underline{S}_1 = T\underline{S}_3 * UNR\underline{M}$

$$DELVLV\underline{C} = \begin{bmatrix} T\underline{S}_1 \\ T\underline{S}_2 \\ T\underline{S}_3 \end{bmatrix} DELVEET\underline{3}$$

Proceed to address specified by SUBEXIT

<u>S34/35.3</u> (Entered from "S34/35.5" if new velocity components input)

$T\underline{S}_2 = - UNR\underline{M}$

$T\underline{S}_3 = - unit\underline{R}_{act3}$

Set bit 4(CONICINT) of FLAGWRD3 = 0

If NOMTPI $\neq$ 0:

Set bit 4(CONICINT) of FLAGWRD3 = 1

T_{decl} = NOMTPI

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

T_{et} = 0

RCV = $\underline{R}_{pprec}$, shifted left X2 places (B29 earth, B27 moon)

VCV = $\underline{V}_{pprec}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{pass3} = \underline{R}_{att}$

$\underline{V}_{pass3} = \underline{V}_{att}$

Proceed to "ELCALC"

S34/35.2 Entered from "HARTBURN", "P34/P74C", and "P35/P75B"

SUBEXIT = Return address

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

If $NN1_{sp}$ = 0:

Set bit 4(CONICINT) of FLAGWRD3 = 1

$T_{decl} = T_{pass4}$

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

T_{et} = INTIME

RCV = $\underline{R}_{pass3}$, shifted left X2 places (B29 earth, B27 moon)

VCV = $\underline{V}_{pass3}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{targ} = \underline{R}_{att}$

Proceed to "S3435.25"

S3435.25

$\underline{V}_{pass4} = \underline{V}_{att}$

$TS_1 = (unit\underline{R}_{act3} * unit\underline{R}_{targ}) \cdot UNR\underline{M}$

$TS = \left(\cos^{-1}(unit\underline{R}_{act3} \cdot unit\underline{R}_{targ})\right) \text{ sgn } TS_1$

If $TS < 0$:

$TS = TS + (1 - 2^{-28})$

ACTCENT = TS

$DELLT4 = T_{pass4} - INTIME$

$TS_1 = NN1_{sp}$

$TS_2 = K_{epsfour}$

$\underline{R}_{init} = \underline{R}_{act3}$

$\underline{V}_{init} = \underline{V}_{act3}$

Perform "INITVEL"

$T\underline{S}_2 = - UNR\underline{M}$

$T\underline{S}_3 = - unit\underline{R}_{act3}$

$T\underline{S}_1 = T\underline{S}_3 * UNR\underline{M}$

$$DELVLV\underline{C} = \begin{bmatrix} T\underline{S}_1 \\ T\underline{S}_2 \\ T\underline{S}_3 \end{bmatrix} DELVEET\underline{3}$$

Proceed to address specified by SUBEXIT

S34/35.3 (Entered from "S34/35.5" if new velocity components input)

$T\underline{S}_2 = - UNR\underline{M}$

$T\underline{S}_3 = - unit\underline{R}_{act3}$

$TS_1 = TS_3 * UNRM$

$$DELVEET3 = DELVLVC \begin{bmatrix} TS_1 \\ TS_2 \\ TS_3 \end{bmatrix}$$

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

Set bit 4(CONICINT) of FLAGWRD3 = 1 (superseding previous line)

$T_{decl} = T_{pass4}$

Set bit 12(MOONFLAG) of FLAGWRDO = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

Set bit 12(MOONFLAG) of FLAGWRDO = 0

$T_{et} = T_{ig}$

$RCV = R_{act3}$, shifted left X2 places (B29 earth, B27 moon)

$VCV = (V_{act3} + DELVEET3)$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$R_{targ} = R_{att}$

$TS_1 = ULOS$

$TS_3 = -\ \mathrm{unit}(ULOS * UNRM)$

$TS_2 = TS_3 * ULOS$

$$DVLOS = \begin{bmatrix} TS_1 \\ TS_2 \\ TS_3 \end{bmatrix} DELVEET3$$

Return

INITVEL (Entered with TS_1, OD, set to iterations; TS_2, 2D, angle to 180°)

Set bit 2(GUESSSW) of FLAGWRD1 = 1

$\underline{R}_{targl} = \underline{R}_{targ}$ (tag to enter here is "HAVEGUES", from "S40.9")

If RTX2 $\neq$ 0: (i.e. not earth-centered)

$\underline{R}_{init} = \underline{R}_{init}$, shifted left 2 places (B27)

$\underline{V}_{init} = \underline{V}_{init}$, shifted left 2 places (B5)

$\underline{R}_{targl} = \underline{R}_{targl}$, shifted left 2 places (B27)

ITCTR = -1

COZY4 = cos TS_2 (TS_2 set before enter, cell 2D)

VTARGTAG = TS_1 (TS_1 set before enter, cell OD)

R1VEC = $\underline{R}_{init}$

R2VEC = $\underline{R}_{targl}$

TDESIRED = DELLT4

$\underline{UN}$ = unit(unit$\underline{R}_{init}$ * $\underline{V}_{init}$)

COZY4 = COZY4 + unit$\underline{R}_{targl}$ · unit$\underline{R}_{init}$

Set bit 10(NORMSW) of FLAGWRD7 = 0

Proceed to "INITVEL2"

INITVEL2

If COZY4 < 0:

Set bit 10(NORMSW) of FLAGWRD7 = 1

R2VEC = |R2VEC| unit (R2VEC - (R2VEC · $\underline{UN}$) $\underline{UN}$)

If ITCTR < 0: (i.e. first pass)

$\underline{R}_{targl}$ = R2VEC

$\underline{TS}$ = - unitR1VEC * unitR2VEC

$TS_1 = RTX1$ (-2 for earth, -10 for lunar)

If $TS_z \geqslant 0$:

$TS_1 = TS_1 - 8$ (-10 for earth, -18 for lunar)

If $TS_1 \neq -10$:

$T\underline{S} = -T\underline{S}$ (i.e. sets to unitR1VE$\underline{C}$ * unitR2VE$\underline{C}$)

$GEOMSGN = 22437_8 \operatorname{sgn}\left((T\underline{S} * unitR1VE\underline{C}) \cdot unitR2VE\underline{C}\right)$

X1 = RTX1

Perform "LAMBERT"

Set bit 2(GUESSSW) of FLAGWRD1 = 0

$\underline{V}_{iprime} = VVE\underline{C}$

If VTARGTAG = 0, proceed to "INITVEL7"

Perform "INTSTALL"

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

If RTX2 $\neq$ 0: (i.e. moon)

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

$R1VE\underline{C} = \underline{R}_{init}$

$RC\underline{V} = \underline{R}_{init}$

$VC\underline{V} = \underline{V}_{iprime}$

$T_{et} = INTIME$

$T_{decl} = T_{et} + DELLT4$

Set bit 4(CONICINT) of FLAGWRD3 = 0

Perform "INTEGRVS"

$\underline{V}_{target} = \underline{V}_{attl}$ (B7 earth, B5 moon)

ITCTR = ITCTR + 1

If ITCTR = VTARGTAG:

$\underline{R}_{targl} = R2VE\underline{C}$

Proceed to "INITVEL7"

$\underline{R2VEC} = \underline{R2VEC} + \underline{R}_{targl} - \underline{R}_{attl}$ (B29 earth, B27 moon)

Proceed to "INITVEL2"

INITVEL7

$\underline{DELVEET3} = \underline{V}_{iprime} - \underline{V}_{init}$

$\underline{V}_{tprime} = \underline{V}_{target}$ ($\underline{V}_{target}$ computed in "INITV" if VTARGTAG = 0)

If RTX2 $\neq$ 0: (i.e. not earth-centered)

$\underline{V}_{tprime} = \underline{V}_{tprime}$, shifted right 2 places

$\underline{V}_{iprime} = \underline{V}_{iprime}$, shifted right 2 places

$\underline{R}_{targl} = \underline{R}_{targl}$, shifted right 2 places

$\underline{DELVEET3} = \underline{DELVEET3}$, shifted right 2 places

$\underline{R}_{targ} = \underline{R}_{targl}$

Set bit 8(XDELVFLG) of FLAGWRD2 = 0

Return (to routine calling "INITVEL")

CSI/A (Entered from "P32/P72B", for P31, P32, and P72)

Set bit 15(S32.1F1) of FLGWRD11 = 0 (causes "CSI/B1" exit if 1 and DELVCSI excessive; if 0, set 1)

Set bit 14(S32.1F2) of FLGWRD11 = 1 (causes "CIRCL" to exit to "FRSTPAS" where bit is reset to 0)

Set bit 13(S32.1F3A) of FLGWRD11 = 0

Set bit 12(S32.1F3B) of FLGWRD11 = 1 (hence bits 13-12 = 01_2)

LOOPCT = 0

CSIALRM = 0

Proceed to "CSI/B"

CSI/B

$$TS = \sqrt{2\ RTMU \Big/ \left(\left|\underline{R}_{actl}\right| \left(1 + \left|\underline{R}_{actl}\right| / \left|\underline{R}_{pass3}\right|\right)\right)}$$

$$DELVCSI = TS - \left(\text{unit}(\underline{UP1} * \text{unit}\underline{R}_{actl})\right) \cdot \underline{V}_{actl}$$

$DELDV = K_{initst}$

Proceed to "CSI/B1"

CSI/B1

LOOPCT = LOOPCT + 1

X2 = 6 (error index)

If LOOPCT − K_{loopmx} $\geqslant$ 0, proceed to "SCNDSOL"

If $|$DELVCSI$|$ − K_{dvmax1} $\geqslant$ 0: (tag here "CSI/B2")

X2 = 7 (error index)

If bit 15(S32.1F1) of FLGWRD11 = 1, proceed to "SCNDSOL"

If bits 13-12 (S32.1F3A and S32.1F3B) of FLGWRD11 = 11_2:

Proceed to "SCNDSOL"

Set bit 15(S32.1F1) of FLGWRD11 = 1 (tag here "CSI/B22")

DELVCSI = K_{dvmax2} sgn DELVCSI

DELVEET$\underline{1}$ = DELVCSI unit(UP$\underline{1}$ * unit$\underline{R}_{act1}$) (tag here "CSI/B23")

$\underline{V}_{act4}$ = DELVEET$\underline{1}$ + $\underline{V}_{act1}$

Reset overflow indicator

X2 = RTX2

VVE$\underline{C}$ = $\underline{V}_{act4}$, shifted left X2 places (B7 earth, B5 moon)

X1 = RTX1

Set bit 9(RVSW) of FLAGWRD7 = 1 (means new $\underline{R}$, $\underline{V}$ not desired)

RVE$\underline{C}$ = $\underline{R}_{act1}$, shifted left X2 places (B29 earth, B27 moon)

SNTH = K_{sn359p}

CSTH = K_{cs359p} (as "y component" of vector load; "z component" loading not effective)

Perform "TIMETHET"

HAFPA1 = $\frac{1}{2}$ T

X1 = RTX1

TS = K_{rpad}

If $X1 \neq -2$: (i.e. not earth)

$TS = |\underline{RLS}|$

XXXALT = TS

Perform "APSIDES"

POSTCSI = $(TS_{rp} - XXXALT)$, shifted right RTX2 places (B29)

If CENTANG $\neq 0$: (loaded in R3 of N55 in "P72" with non-zero value to force transfer)

Proceed to "CIRCL"

If $ECC - K_{onethth} < 0$: (ECC computed in "APSIDES")

Proceed to "CIRCL" (due to ECC scaling, exit taken if below about 0.000488, i.e. 2^{-11})

TS = R1, shifted right RTX2 places (B29) (R1 has $|\underline{RVEC}|$ due to "APSIDES", i.e. $|\underline{R}_{act1}|$)

If $|(\underline{R}_{act1} \cdot \underline{V}_{act4})| / TS - K_{nickeldp} < 0$: (constant is 7 fps)

Proceed to "CIRCL"

$TS_{1_y} = P - 1$ (scaled B2, in PD 14D)

$TS_2 = P\ R1$, shifted right RTX2 places (B33)

$TS_3 = \sqrt{TS_2}$ (RTSR1dMU / TS) (B-31 earth, B-28 moon: TS_2 rescaled to B28 before root)

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift TS_3 left 3 places (make B-31)

$RDOTV = \underline{R}_{act1} \cdot \underline{V}_{act4}$ (tag here "CSI/B3")

$TS_{1_x} = |RDOTV|\ TS_3$ (scaled B2, in PD 12D)

$TS_{1_z} = 0$ (in PD 16D)

$T\underline{S} = \text{unit}T\underline{S}_1$

$SNTH = TS_x$

$CSTH = TS_y$ ("z component" loading not effective)

X2 = RTX2

$\underline{VVEC} = -\underline{V}_{act4}$ sgn RDOTV, shifted left X2 places (B7 earth, B5 moon)

X1 = RTX1

Set bit 9(RVSW) of FLAGWRD7 = 1 (means new $\underline{R}$, $\underline{V}$ not desired)

$\underline{RVEC} = \underline{R}_{act1}$, shifted left X2 places (B29 earth, B27 moon)

Perform "TIMETHET"

TS = T

$T_{csi2} = T_{csi} + T$ (ineffective, since written over below)

If RDOTV < 0:

TS = HAFPA1 - TS

Proceed to second line of "CIRCL"

<u>CIRCL</u>

TS = 0

$T_{csi2} = T_{csi} + 2$ HAFPA1 (Tag here "NTP/2")

If NN1 = 4:

$T_{csi2} = T_{csi2} +$ HAFPA1

$T_{cdh} =$ NN1 HAFPA1 - TS + T_{csi} (Tag here "NTP/2A")

X2 = 5 (error index)

If $(T_{tpi} - T_{cdh}) < 0$:

Proceed to "SCNDSOL"

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

Set bit 4(CONICINT) of FLAGWRD3 = 1 (superseding previous line)

$T_{decl} = T_{cdh}$

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

$T_{et} = T_{csi}$

$\underline{RCV} = \underline{R}_{act1}$, shifted left X2 places (B29 earth, B27 moon)

$\underline{VCV} = \underline{V}_{act4}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{act2} = \underline{R}_{att}$

$\underline{V}_{act2} = \underline{V}_{att}$

Perform "INTSTALL" (tag here "CSINEXT1")

Set bit 4(CONICINT) of FLAGWRD3 = 0

Set bit 4(CONICINT) of FLAGWRD3 = 1 (superseding previous line)

$T_{decl} = T_{cdh}$

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

    Set bit 12(MOONFLAG) of FLAGWRD0 = 0

$T_{et} = T_{csi}$

RC$\underline{V}$ = $\underline{R}_{pass1}$, shifted left X2 places (B29 earth, B27 moon)

VC$\underline{V}$ = $\underline{V}_{pass1}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{pass2} = \underline{R}_{att}$

$\underline{V}_{pass2} = \underline{V}_{att}$

Perform "CDHMVR"

X2 = RTX2

VVE$\underline{C}$ = $\underline{V}_{act3}$, shifted left X2 places (B7 earth, B5 moon)

RVE$\underline{C}$ = $\underline{R}_{act2}$, shifted left X2 places (B29 earth, B27 moon)

X1 = RTX1

$TS = K_{rpad}$

If X1 $\neq$ -2: (i.e. not earth)

    TS = $|$RL$\underline{S}|$

XXXALT = TS

Perform "APSIDES"

POSTCDH = (TS_{rp} - XXXALT), shifted right RTX2 places (B29)

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

Set bit 4(CONICINT) of FLAGWRD3 = 1 (superseding previous line)

$T_{decl} = T_{tpi}$

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

X2 = RTX2

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

    Set bit 12(MOONFLAG) of FLAGWRD0 = 0

$T_{et} = T_{cdh}$

$RC\underline{V} = \underline{R}_{act2}$, shifted left X2 places (B29 earth, B27 moon)

$VC\underline{V} = \underline{V}_{act3}$, shifted left X2 places (B7 earth, B5 moon)

Perform "INTEGRVS"

$\underline{R}_{act3} = \underline{R}_{att}$

$\underline{V}_{act3} = \underline{V}_{att}$

$PDU\underline{L} = \text{unit}\underline{R}_{act3} \sin ELEV + \text{unit}(UP\underline{1} * \text{unit}\underline{R}_{act3}) \cos ELEV$

$PDC1 = PDU\underline{L} \cdot \underline{R}_{act3}$ (tag here "CSINEXT2")

$PDC2 = \underline{R}_{pass3} \cdot \underline{R}_{pass3} - \underline{R}_{act3} \cdot \underline{R}_{act3} + PDC1^2$ (formed triple precision)

If PDC2 < 0:

    X2 = 1 (error index)

    If LOOPCT = 1:

        CSIALRM = X2

        Proceed to "ALMXIT"

    DELDV = $\frac{1}{2}$ DELDV

    DELVCSI = DVPREV - DELDV

    Proceed to "CSI/B1"

$PCDK2 = - PDC1 - \sqrt{PDC2}$ (tag here "K1ORK2")

$PCDK1 = - PDC1 + \sqrt{PDC2}$

PCDK = PCDK2 (same cell)

If $|PCDK2| - |PCDK1| \geq 0$:

PCDK = PCDK1

$PDU\underline{B} = \text{unit}(PCDK\ PDU\underline{L} + \underline{R}_{act3})$

$TS = (\text{unit}\underline{R}_{pass3} * PDU\underline{B}) \cdot (\text{unit}\underline{V}_{pass3} * \text{unit}\underline{R}_{pass3})$

$PCDGAMMA = \cos^{-1} (\text{unit}\underline{R}_{pass3} \cdot PDU\underline{B}) \text{ sgn } TS$

If bit 14(S32.1F2) of FLGWRD11 = 1:

Proceed to "FRSTPAS"

PDSL = (PCDGAMMA - GAMPREV) / (DELVCSI - DVPREV)

DVPREV = DELVCSI

If bits 13-12 (S32.1F3A and S32.1F3B) of FLGWRD11 = 11_2:

If GAMPREV (PCDGAMMA - GAMPREV) < 0:

$DELDV = K_{initstl} \text{ sgn } DELDV$

Set bits 13-12 (S32.1F3A and S32.1F3B) of FLGWRD11 = 10_2

Proceed to "FRSTPAS"

Proceed to "FIFTYFPS"

If bits 13-12 (S32.1F3A and S32.1F3B) of FLGWRD11 = 00_2: (tag "THRDCHK")

Proceed to "FIFTYFPS"

DELDV = PCDGAMMA / PDSL (tag here is "NEWTN")

GAMPREV = PCDGAMMA

If $|DELDV| - K_{epsiln1} \geq 0$:

If $|DELDV| - K_{delmax1} \geq 0$:

$DELDV = K_{delmax1} \text{ sgn } DELDV$

DELVCSI = DELVCSI - DELDV (tag here is "CSISTEP")

Proceed to "CSI/B1"

$X2 = 2$ (error index) (tag here is "CSI/SOL")

$X1 = RTX1$ (-2 for earth, - 10 for moon)

If $POSTCSI - K_{pmine_{-2-X1}} < 0$: (subscript 0 for earth, 8 for moon)

Proceed to "SCNDSOL"

$X2 = 3$ (error index)

If $POSTCDH - K_{pmine_{-2-X1}} < 0$:

Proceed to "SCNDSOL"

$T1TOT2 = T_{cdh} - T_{csi}$

$X2 = 4$ (error index)

If $T1TOT2 - K_{600sec} < 0$:

Proceed to "SCNDSOL"

$X2 = 5$

$TS = T_{tpi} - T_{cdh} - K_{600sec}$

If $TS < 0$:

Proceed to "SCNDSOL"

Proceed to "P32/P72C" (successful return)

FRSTPAS

GAMPREV = PCDGAMMA

DVPREV = DELVCSI

DELVCSI = DELVCSI - DELDV

Set bit 14(S32.1F2) of FLGWRD11 = 0

Proceed to "CSI/B1"

FIFTYFPS

$DELDV = K_{fifpsdp}$ sgn PDSL sgn GAMPREV (constant is - 50 fps)

DELVCSI = DELVCSI - DELDV

Set bits 13-12 (S32.1F3A and S32.1F3B) of FLGWRD11 = 11_2

GAMPREV = PCDGAMMA

Proceed to 4th line of "CSI/B1"

<u>SCNDSOL</u>

If bits 13-12 (S32.1F3A and S32.1F3B) of FLGWRD11 $\neq 01_2$:

Proceed to "ALMXIT"

CSIALRM = X2

Set bit 15(S32.1F1) of FLGWRD11 = 0

Set bit 14(S32.1F2) of FLGWRD11 = 1

Set bits 13-12 (S32.1F3A and S32.1F3B) of FLGWRD11 = 00_2

LOOPCT = 0

Proceed to "CSI/B"

<u>ALMXIT</u>

$TS = K_{alarmtb_{CSIALRM-1}}$

Perform "VARALARM"

$TS = 0509_{vn}$ (Note that if in P31 and do not V32, bit 7(HAFLAG) of FLGWRD11 would remain set, inhibiting P32/P72)

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to previous line
otherwise, proceed

Proceed to 2nd line of "P72"

<u>CDHMVR</u> Entered from "CIRCL", "HARTBURN", and "P33/P73B"

$UNVE\underline{C} = \text{unit}\underline{R}_{act2}$

$CSTH = \text{unit}\underline{R}_{pass2} \cdot UNVE\underline{C}$

$SNTH = \sqrt{1 - CSTH^2}\ \text{sgn}\left((-\underline{R}_{act2} * \underline{R}_{pass2}) \cdot UP\underline{1} \right)$

X2 = RTX2

$VVE\underline{C} = \underline{V}_{pass2}$, shifted left X2 places (B7 earth, B5 moon)

$X1 = RTX1$

Set bit 9(RVSW) of FLAGWRD7 = 0 (means new $\underline{R}$, $\underline{V}$ are desired)

$RVE\underline{C} = \underline{R}_{pass2}$, shifted left X2 places (B29 earth, B27 moon)

Perform "TIMETHET"

$PD18\underline{V} = T\underline{S}_v$, shifted right RTX2 places (B7)

$PD02R = |T\underline{S}_r|$, shifted right RTX2 places (B29)

$DIFFALT = PD02R - |\underline{R}_{act2}|$

TS = R1, shifted right RTX2 places (B29)

$PDSEMAP = TS / RdA$ (gives semi-major axis of passive vehicle)

$PDSEMAA = PDSEMAP - DIFFALT$

$PDVAV = (PD18\underline{V} \cdot UNVE\underline{C}) \ (PDSEMAP / PDSEMAA)^{3/2}$

$TS = 2 \ RTMU / |\underline{R}_{act2}| - RTMU / PDSEMAA$

$PDVAH = \sqrt{TS - PDVAV^2}$

$\underline{V}_{act3} = PDVAH \ unit(UP\underline{1} * UNVE\underline{C}) + PDVAV \ UNVE\underline{C}$

$DELVEET\underline{2} = \underline{V}_{act3} - \underline{V}_{act2}$

Return

Quantities in Computations

See also list of major variables and list of routines

ACTCENT: Value of active vehicle central angle of transfer computed in "S3435.25" (entered for P34/P74 and P35/P75), scale factor B0, units revolutions, in range 0 - 360°. It can be displayed at crew option in R1 of N52: if too close to 180°, then the maneuver parameters should be reconsidered.

AUTOY: See Burn Control.

CENTANG: See Burn Control.

CMYDOT: See Burn Control.

COZY4: Criterion used in "INITVEL2" to decide if input position vector and target position vector are too close to 180 degrees, scale factor B2. It is initially loaded with the cosine of TS_2 in "INITVEL", where TS_2, stored in push-down list location 2D as an angle, B0 revolutions, is angle away from 180° within which "INITVEL2" rotates the target vector to be in the plane of $\underline{R}_{init}$ and $\underline{V}_{init}$. Before entering "INITVEL2", COZY4 is changed to be the sum of the cosine and the dot product of the initial and original target vectors (hence if it is negative, then the "INITVEL2" logic must be invoked: e.g. if TS_2 set to 15 degrees, then an angle of 165° to 195° would cause the R2VE$\underline{C}$ rotation). If outside the cone, then NORMSW is left at 0, causing "LAMBERT" (in "GEOM") to compute a U$\underline{N}$ as perpendicular to original and target position vectors.

CSIALRM: Cell used single precision (although initialization to 0 is done double precision), scale factor B14, to contain the value of the index used with $K_{alarmtb}$ to generate a program alarm in "ALMXIT". If "SCNDSOL" is entered for an alarm condition but bits 13-12 of FLGWRD11 indicate that computation starting (value of 01_2), then CSIALRM loaded with the cause of that entrance to "SCNDSOL"; a subsequent entrance, perhaps for a different reason, would cause "ALMXIT" to display the <u>first</u> alarm code.

CSTH: See Conic Routines.

DELDV: Value of required change to DELVCSI, scale factor B7, units meters/centi-second.

DELEL: Value of error between derived and specified values of elevation angle in "ELCALC", scale factor B0, units revolutions.

DELELO: Value of previous DELEL, scale factor B0, units revolutions, in 26D.

DELLT4: Communication cell with "INITVEL", containing desired time of flight from $\underline{R}_{init}$ to $\underline{R}_{targ}$, scale factor B28, units centi-seconds. It is loaded into TDESIRED for use in Lambert routine.

DELTEEO: Value of time increment information in "ELCALC" (generally the value added to NOMTPI), scale factor B28, units centi-seconds.

DELVCSI: Magnitude of velocity change required for the CSI burn (as determined in "CSI/B"), scale factor B7, units meters/centi-second. The vector velocity is DELVEET1, although the latter quantity can be superseded if desired by loading new velocity components for the N81 display in "P32/P72C". This revised loading would not be reflected in DELVEET1, however.

DELVEET1: Vector velocity change required for the CSI burn, scale factor B7, units meters/centi-second. Magnitude is in DELVCSI. It can be superseded in "P32/P72C" by loading new velocity components for the N81 display, and it is computed near the start of "CSI/B1". Has CDH in P33/73.

DELVEET2: Vector velocity change required for the CDH burn, scale factor B7, units meters/centi-second, computed in "CDHMVR". It can be superseded in "P33/P73B" by loading new velocity components for the N81 display. The value of the quantity may also be displayed in "P32/P72C" (in local vertical coordinates) as originally derived (i.e. not modified due to manual writeover, if any, of DELVEET1 information).

DELVEET3: Vector velocity increment required to perform maneuver, computed in "INITVEL7" (as $\underline{V}_{iprime} - \underline{V}_{init}$). When exit from "INITVEL7", scale factor is B7, units meters/centi-second. A new value is computed in "S34/35.3" from local-vertical inputs if required. DELVSIN same cell.

DELVLVC: See Burn Control.

DIFFALT: Difference in altitude between passive and active vehicles at CDH time (negative if active above passive vehicle), scale factor B29, units meters, computed in "CDHMVR". It is displayed in R1 of N75.

DVLOS: See Burn Control.

DVPREV: Previous value of DELVCSI, scale factor B7, units meters/centi-second.

ECC: See Conic Routines.

ELEV: Value of elevation angle between the active/passive vehicle line of sight and the active vehicle local horizontal at TPI ignition time, referenced to the direction of flight, scale factor B0, units revolutions (in range 0 degrees to 360 degrees). An input value of 0 in P34/P74 causes the angle to be derived from the specified time; a non-zero value causes the TPI time to be derived (in the routine beginning at "S33/34.1").

GAMPREV: Previous value of PCDGAMMA, scale factor B1, units revolutions.

GEOMSGN: See Conic Routines. The magnitude of the number is not significant (provided non-zero), but only the sign: the magnitude loaded in "INITVEL2", for programming convenience, is the most significant half of K_{muer_0} (see Orbital Integration).

HAFPA1: Value of half the period of the active vehicle after completion of the CSI maneuver, scale factor B28, units centi-seconds, computed in "CSI/B1". It is used in "CIRCL" to determine T_{cdh} and T_{csi2}.

INTIME: Communication cell with "INITVEL" containing the time tag of the state vector in $\underline{R}_{init}$ and $\underline{V}_{init}$, scale factor B28, units centi-seconds. Not required if VTARGTAG = 0.

ITCTR: Single precision counter, scale factor B14, of the number of iterations of "INITVEL" computations which have been performed. It is set to an initial condition of -1, so that a value of +1, for example, would mean that 2 passes thru "LAMBERT" and "INTEGRVS" are performed, with the output of "LAMBERT" used in the "INTEGRVS" routine to refine the target position. The desired number of iterations is specified by the contents of VTARGTAG.

K_{600sec}: See Orbital and Rendezvous Navigation.

$K_{alarmtb_i}$ (i = 0 - 6): Set of single precision octal constants, program notation (i = 0) "ALARM/TB", used in "ALMXIT" to specify the alarm pattern based on (CSIALRM - 1). Value of constants is equal to (600_8 + i): if CSIALRM = 3, for example, then alarm 602_8 is provided. Alarm 600_8 is generated in "CIRCL" if PDC2 negative on first pass (LOOPCT = 1), meaning no intersection of desired TPI LOS with the necessary circle (this is the only alarm not buffered via "SCNDSOL", see CSIALRM); Alarms 601_8 - 604_8 are generated at the end of "CIRCL" for CSI periapsis too small, CDH periapsis too small, T1TOT2 too small, and T2TOT3 too small respectively (604_8 also generated at start of "CIRCL" if T_{cdh} greater than T_{tpi}); Alarm 605_8 is generated near the start of "CSI/B1" if LOOPCT is not less than K_{loopmx}; and Alarm 606_8 is generated at same point if DELVCSI magnitude excessive and bit 15(S32.1F1) of FLGWRD11 = 1.

K_{cs359p}: Constant, program notation "CS359+", scale factor B1, octal value 17777_8 37776_8, corresponding to a true value of $(1 - 2^{-26})$. Used in "CSI/B1" to set CSTH for "TIMETHET", so as to compute the period of the orbit (see K_{sn359p}), i.e. an angle of $\sim 360^o$.

$K_{delmax1}$: Constant, program notation "DELMAX1", scale factor B7, units meters/centi-second. Value is 0.6096×2^{-7}, corresponding to $200 \times 0.3048 \times 10^{-2} \times 2^{-7}$, where first term is value in fps, second converts to meters, third converts to centi-seconds, and 4th is scale factor.

K_{dvmax1}: Constant, program notation "DVMAX1", scale factor B7, units meters/centi-second. Value is 3.048×2^{-7}, corresponding to $1000 \times 0.3048 \times 10^{-2} \times 2^{-7}$, where first term is value in fps, second converts to meters, third converts to centi-seconds, and 4th is scale factor.

K_{dvmax2}: Constant, program notation "DVMAX2", scale factor B7, units meters/centi-second. Value is 3.014472×2^{-7}, corresponding to $989 \times 0.3048 \times 10^{-2} \times 2^{-7}$, where first term is value in fps, second converts to meters, third converts to centi-seconds, and 4th is scale factor.

K_{eeps}: Constant, program notation "ELEPS", scale factor B0, units revolutions. Value is 0.27777777E-3, corresponding to 0.1^o.

$K_{epsfour}$: Constant, program notation "EPSFOUR", scale factor B0, units revolutions. Value is 0.0416666666, corresponding to 15^o.

$K_{epsilnl}$: Constant, program notation "EPSILN1", scale factor B7, units meters/centi-second. Value is 3.048E-4 x 2^{-7}, corresponding to 0.1 x 0.3048 x 10^{-2} x 2^{-7}, where first term is value in fps, second converts to meters, third converts to centi-seconds, and 4th is scale factor.

$K_{fifpsdp}$: Constant, program notation "FIFPSDP", scale factor B7, units meters/centi-second. Value is -0.1524 x 2^{-7}, corresponding to - 50 x 0.3048 x 10^{-2} x 2^{-7}, where first term is value in fps, second converts to meters, third converts to centi-seconds, and 4th is scale factor.

K_{initst}: Constant, program notation "INITST", scale factor B7, units meters/centi-second. Value is 0.03048 x 2^{-7}, corresponding to 10 x 0.3048 x 10^{-2} x 2^{-7}, where first term is value in fps, second converts to meters, third converts to centi-seconds, and 4th is scale factor.

$K_{initstl}$: Constant, program notation "INITST1", scale factor B7, units meters/centi-second. Value is 0.03048 x 2^{-7}, the same as K_{initst}. Stored in a separate memory cell in "high" part of memory because of memory allocation constraints (and interpretive language limitations).

K_{loopmx}: Constant, program notation "LOOPMX", scale factor B28. Octal value is 00000_8 00020_8, corresponding to decimal 16 (giving an error exit from the start of "CSI/B1" after 15 complete iterations done).

K_{max250}: Constant, program notation "MAX250", scale factor B28, units centi-seconds. Value is 25E3 x 2^{-28}, corresponding to 250 seconds.

$K_{nickeldp}$: Constant, program notation "NICKELDP", scale factor B7, units meters/centi-second. Value is 0.021336 x 2^{-7}, corresponding to 7 x 0.3048 x 10^{-2} x 2^{-7}, where first term is value in fps, second converts to meters, third converts to centi-seconds, and 4th is scale factor. Value of constant originally corresponded to 0.05 fps, hence the notation.

$K_{onethth}$: Constant, program notation "ONETHTH", scale factor B3, value 0.0001 x 2^{-3} (first term is basic value and second scale factor).

K_{pmine_0}: Constant, program notation "PMINE", scale factor B29, units meters, giving the minimum periapsis value (POSTCDH and POSTCSI) for earth-centered computations. Value is 157420 x 2^{-29}, corresponding to 85 x 1852 x 2^{-29}, where first term is value in nmi, second converts to meters, and third is scale factor.

K_{pmine_8}: Constant, program notation "PMINM" (stored at "PMINE" + 8), scale factor B29, units meters, giving the minimum periapsis value for moon-centered computations. Value is 10668 x 2^{-29}, corresponding to 35000 x 0.3048 x 2^{-29}, where first term is value in feet, second converts to meters, and third is scale factor.

K_{rpad}: See Burn Control.

K_{sn359p}: Constant, program notation "SN359+", scale factor B1, value -0.000086601. True value is -0.000173202, or approximately sin 359.99°: see K_{cs359p}.

K_{twopi}: Constant, program notation "TWOPI", scale factor B4, value $6.283185307 \times 2^{-4}$, corresponding to 2π (where $\pi = 3.1415926535$).

LMYDOT: See Burn Control.

LOOPCT: Iteration counter for "CSI/A" computations, initialized to 0 in "CSI/A" and "SCNDSOL", scale factor B28.

NN1: Value of "periapsis code" displayed by R1 of N55, scale factor B14, program notation also "NN". Used in P31/P32/P72 (where initialized to 1 prior to N55 display) to specify the future apsidal crossing of the active vehicle at which CDH should occur. Used in "P82" in the control of Minkey program sequencing, although the attempted "countdown" of the cell there is ineffective since bit 6(CSISFLAG) of FLGWRD11 = 0. Used in P34/P74 to specify the number of precision offsets that the "INITVEL" package should employ (it is initialized to 0 in "P74" and used in "S3435.25"). The P34/P74 value would be used for the subsequent P35/P75 performance. The identification as "periapsis code" is a hold-over from the former P17 application.

NOMTPI: Value of computed correction to T_{tpi}, scale factor B28, units centi-seconds, loaded in "ELCALC". This scheme permits $\underline{R}_{aprec}/\underline{R}_{pprec}$ state vector time tag to remain T_{tpi} while the iteration continues for the proper updated value of T_{tpi}, using conic integration.

P: See Conic Routines.

PCDGAMMA: Error angle used in the "CSI/A" computations, scale factor B1, units revolutions, stored in push-down list location 0D. It is the central angle between the passive vehicle position vector at TPI and PDU$\underline{B}$.

PCDK: Value of "weight" for PDU$\underline{L}$ in computing PDU$\underline{B}$, scale factor B29, units meters, corresponding to the lesser (in magnitude) of PCDK1 and PCDK2. Stored in push-down location 10D.

PCDK1: Value corresponding to one of the solutions of the equation for PCDK, scale factor B29, units meters, stored in push-down location 12D. Equation solved for "k" is: $k^2 + 2\, c_1\, k + \underline{r}_{a3}^{\,2} - \underline{r}_{p3}^{\,2} = 0$.

PCDK2: Value corresponding to the other solution of the quadratic equation for PCDK, scale factor B29, units meters, stored in push-down location 10D (written over with PCDK1 if necessary to determine PCDK).

PD02R: Value of magnitude of passive vehicle position vector used in "CDHMVR" to compute DIFFALT, scale factor B29, units meters. Stored in push-down location 02D (cell contents replaced by magnitude of $\underline{R}_{act2}$ after use).

PD18$\underline{V}$: Value of passive vehicle velocity vector used in "CDHMVR", scale factor B7, units meters/centi-second. It is the velocity vector at the point corresponding to PD02R (i.e. radially above/below the active vehicle), and is stored in push-down location 18D.

PD28CS: Value of ratio of active to passive vehicle radius magnitudes times cos ELEV (i.e. times - cos ($\frac{1}{2}$ - ELEV)), scale factor B1, stored in push-down list location 28D.

PDALFMPI: Value of guidance equation quantity α minus π, scale factor B0, units revolutions, stored in push-down list location 18D.

PDC1: Value of equation quantity "c_1" (see PCDK1) for quadratic equation in "CIRCL", scale factor B29, units meters, stored in push-down location 6D.

PDC2: Value of equation quantity "c_2" (the quantity under the radical for the quadratic equation defined in PCDK1 definition), scale factor B58, units meters^2; square root stored temporarily in push-down list.

PDDELTM: Value of guidance equation quantity δt, scale factor B28, units centi-seconds, stored in push-down list location 12D.

PDOMEGA: Value of active vehicle angular velocity information times radius magnitude ratio (for convenience in scaling), scale factor B37, stored temporarily in push-down list. Push-down(16D) list subsequently modified to contain PDOMEGA - PDOMEGP, with scale factor information in X1 also (i.e. scaling B(37 +X1)).

PDOMEGP: Value of passive vehicle angular velocity information times radius magnitude ratio (for convenience in scaling: the reciprocal of the ratio used for PDOMEGA is employed), scale factor B37, stored as described under PDOMEGA.

PDSEMAA: Value of semi-major axis of active vehicle computed in "CDHMVR", scale factor B29, units meters, stored in push-down location 4D.

PDSEMAP: Value of semi-major axis of passive vehicle computed in "CDHMVR", scale factor B29, units meters, stored temporarily in push-down location 4D (then that location used for PDSEMAA).

PDSL: Value of "slope" function for "CIRCL" iteration (DELDV for next cycle is given by PCDGAMMA / PDSL), scale factor B-6 (for variables already normalized), stored in push-down location 4D.

PDU$\underline{B}$: Value of equation "b" vector, scale factor B1, stored in push-down location 0D. It represents the position where the passive vehicle "should be based on the active vehicle location", and is used to compute PCDGAMMA.

PDU$\underline{L}$: Value of equation "u_L" vector, scale factor B1, stored in push-down location 0D. It gives the "unit vector which passes through the active vehicle position and is coincident with the desired TPI line of sight" (specified by ELEV).

PDVAH: Value of "horizontal" component of required active vehicle velocity after CDH maneuver, computed in "CDHMVR". Scale factor is B7, units meters/centi-second, and stored in push-down location 10D.

PDVAV: Value of "vertical" (i.e. radial) component of required active vehicle velocity after CDH maneuver, computed in "CDHMVR". Scale factor is B7, units meters/centi-second, and stored in push-down location 8D.

POSTCDH: Value of periapsis altitude after performance of CDH maneuver, scale factor B29, units meters. It is computed in "CIRCL" for use at end of iteration to check that the 85 nmi/35,000 feet minimum value constraint not violated. It is not computed in P33/P73.

POSTCSI: Value of periapsis altitude after performance of CSI maneuver, scale factor B29, units meters. It is computed in "CSI/B1" for use at end of iteration to check that minimum value constraint not violated.

$\underline{R}_{act1}$: Value of active vehicle position vector, scale factor B29, units meters, initialized in "ADVANCE" to be equal to the active vehicle vector at the specified T_{ig} (T_{csi} or T_{cdh}), rotated into the plane of the passive vehicle. Loaded near end of "P32/P72C" with $\underline{R}_{act2}$ to permit use of a common subroutine.

$\underline{R}_{act2}$: Value of active vehicle position vector, scale factor B29, units meters. Initialized in "ADVANCE" to $\underline{R}_{act1}$, and written over in "CIRCL" with computed CDH state vector. The quantity is used in "CDHMVR" as the active vehicle position vector at CDH.

$\underline{R}_{act3}$: Value of active vehicle position vector, scale factor B29, units meters. Computed in "PRECSET" for the input-specified time, and used in "ADVANCE" for initializing active vehicle vectors at that time. Is updated in "CIRCL" to be the active vehicle position vector at TPI time: this is also the meaning of the quantity in P34/P74, for example. A similar update is done in "P33/P73B".

$\underline{R}_{aprec}$: Value of $\underline{R}_{act3}$ at entrance to "S33/34.1", used to form a standard initial condition for performance of conic integration in "ADTIME+3" by the amount of time in NOMTPI (to avoid buildup of error due to successive conic computations), scale factor B29, units meters.

$\underline{R}_{init}$: Value of position vector at start of burn (or of Lambert evaluation), used as a communication cell with "INITVEL", scale factor B29, units meters. "INITVEL" scales to B27 if moon-centered. If iteration is required, the time tag for the state vector is in INTIME.

$\underline{R}_{pass1}$: Value of passive vehicle position vector, scale factor B29, units meters, initialized in "ADVANCE" to be equal to the passive vehicle position vector at the specified T_{ig} (T_{csi} or T_{cdh}).

$\underline{R}_{pass2}$: Value of passive vehicle position vector, scale factor B29, units meters, initialized in "ADVANCE" to $\underline{R}_{pass1}$. It is written over in "CIRCL" with the computed passive vehicle state vector at CDH, and it is used in "CDHMVR" as the passive vehicle state vector then.

$\underline{R}_{pass3}$: Value of passive vehicle position vector, scale factor B29, units meters. Computed in "PRECSET" for the input-specified time, and used in "ADVANCE" for initializing active vehicle vectors at that time. Is updated in "P32/P72B" (before entrance to "CSI/A") to be the passive vehicle position vector at TPI time; a similar update is done in "P33/P73B" after CDH maneuver parameters obtained.

$\underline{R}_{pprec}$: Value of $\underline{R}_{pass3}$ at entrance to "S33/34.1", used to form a standard initial condition for performance of conic integration in "ADTIME+3", scale factor B29, units meters (see $\underline{R}_{aprec}$).

$\underline{R}_{targ}$: Communication cell with "INITVEL" containing position of target vector (or vehicle) DELLT4 centi-seconds after the time in INTIME, scale factor B29, units meters. Loaded with updated target vector position (if a change made) before exit from routine.

$\underline{R}_{targ1}$: Value of $\underline{R}_{targ}$ used within "INITVEL" package, scale factor (after rescaling) B29(earth) or B27(moon), units meters. B29 when exit.

R1: See Conic Routines.

R1VE$\underline{C}$, R2VE$\underline{C}$: See Conic Routines.

RC$\underline{V}$: See Orbital Integration.

RdA: See Conic Routines.

RDOTV: Value of $\underline{R}_{act1} \cdot \underline{V}_{act4}$ computed in "CSI/B1", scale factor B36, units meters^2/centi-second.

RL$\underline{S}$: See Coordinate Transformations.

RTMU, RTSR1dMU: See Burn Control.

RTX1, RTX2: See Orbital Integration (cells loaded at start of most P3i/P7i programs with index information for X1 and X2 respectively, selecting earth if -2 and 0; moon if -10 and 2).

RVE$\underline{C}$: See Conic Routines.

SECMAX: Value of maximum time increment used in iteration for TPI time, scale factor B28, units centi-seconds. Initialized to K_{max250} in "S33/34.1".

SNTH: See Conic Routines.

SUBEXIT: Single precision cell used to retain return address information from "S34/35.2".

T: See Conic Routines.

T_{cdh}: Value of ignition time for CDH maneuver, scale factor B28, units centi-seconds. It is derived in "CIRCL", and displayed by N13.

T_{csi}: Value of ignition time for CSI maneuver, scale factor B28, units centi-seconds, loaded via N11 at start of P31/P32/P72. Loaded with T_{csi2} in "P82".

T_{csi2}: Value of ignition time for subsequent CSI maneuver computed in "CIRCL", scale factor B28, units centi-seconds, loaded into T_{csi} in "P82".

T_{dec2}: Value of time to which integration is to be performed by "PRECSET", scale factor B28, units centi-seconds. Used to achieve the same T_{dec1} setting for the CSM integration as for the LM integration.

T_{et}: See Orbital Integration.

T_{pass4}: See Burn Control.

T_{tpi}: Value of Transfer Phase Initiation (TPI) time, scale factor B28, units centi-seconds. Can be input to P34/P74 from e.g. P33/P73 derived value, although it can also be computed in P34/P74 to give a specified elevation angle value. If it is to be derived, the iteration starts in P34/P74 with the specified T_{tpi}.

T1TOT2: Value of time interval for P32/P72 between T_{csi} and T_{cdh} computed at the end of "CIRCL", scale factor B28, units centi-seconds. To permit display in R2 of N75, made modulo one hour in "P32/P72C". In P33/P73, it is the time interval between T_{cdh} and T_{tpi} (computed in "P33/P73B", and made modulo one hour only if positive).

T2TOT3: Value of time interval between T_{cdh} and T_{tpi} for P32/P72, scale factor B28, units centi-seconds, displayed in R3 of N75. It is derived in "CIRCL" but loaded in "P32/P72C", where made modulo one hour. In P33/P73, it is the value of (T_{tpi} - T_{tpiO}), the change in TPI time between P32/P72 and P33/P73, computed in "P33/P73B", where it is also made modulo one hour.

TDESIRED: See Conic Routines.

TITER: Single precision cell used in "S33/34.1" to protect against excessive iterations. Initialized to a negative number, and then reset in "ELCALC" (where used as flag for first pass) to 37777_8. Subsequently shifted right 1 place if DELEL not less than K_{eeps}: the 15th right shift will make the single precision value zero (double precision one non-zero, serving as error flag), causing an error exit.

ULOS: Value of unit vector, scale factor B1, in line-of-sight direction (direction of $\underline{R}_{pass3}$ - $\underline{R}_{act3}$).

UN: See Conic Routines. Computed in "INITVEL" as perpendicular to plane defined by $\underline{R}_{init}$ and $\underline{V}_{init}$, but is written over in Lambert routine (in subroutine "GEOM") if the NORMSW (bit 10 of FLAGWRD7) is 0 (meaning that transfer not too close to 180 degrees as defined by COZY4 information).

UNRM: Value of unit vector, scale factor B1, perpendicular to $\underline{R}_{act3}$ and $\underline{V}_{act3}$ (i.e. in $\underline{R}$ * $\underline{V}$ direction).

UNVEC: Unit vector formed from $\underline{R}_{act2}$ at the start of "CDHMVR", scale factor B1.

UP: Unit vector, scale factor B1, giving direction of "local horizontal plane of active vehicle at T_{tpi}" for use in computing ELEV in "ELCALC", stored in push-down list location OD.

UP1: Unit vector, scale factor B1, computed in "PRECSET" in direction of $\underline{r}_p$ * $\underline{v}_p$ (the passive vehicle position and velocity vectors at the specified ignition time).

$\underline{V}_{act1}$: Value of active vehicle velocity vector, scale factor B7, units meters/centi-second, initialized in "ADVANCE" to be equal to the active vehicle vector at the specified T_{ig} (T_{csi} or T_{cdh}), rotated into the plane of the passive vehicle.

$\underline{V}_{act2}$: Value of active vehicle velocity vector, scale factor B7, units meters/centi-second. Initialized in "ADVANCE" to $\underline{V}_{act1}$, and written over in "CIRCL" with computed CDH state vector. The quantity is used in "CDHMVR" as active vehicle velocity vector at CDH.

$\underline{V}_{act3}$: Value of active vehicle velocity vector, scale factor B7, units meters/centi-second. Computed in "PRECSET" for the input-specified time, and used in "ADVANCE" for initializing active vehicle vectors at that time. It is loaded at the end of "CDHMVR" with the required velocity after the CDH maneuver, and this value in "CIRCL" in turn is written over with the active vehicle velocity at TPI (which is also the meaning of the quantity in P34/P74). A similar writeover is done in "P33/P73B".

$\underline{V}_{act4}$: Value of active vehicle velocity vector, scale factor B7, units meters/centi-second, after performance of CSI maneuver (computed in "CSI/B1").

$\underline{V}_{aprec}$: Value of $\underline{V}_{act3}$ at entrance to "S33/34.1", scale factor B7, units meters/centi-second (see $\underline{R}_{aprec}$).

$\underline{V}_{init}$: Value of velocity vector at start of burn (or of Lambert evaluation), used as a communication cell with "INITVEL", scale factor B7, units meters/centi-second. "INITVEL" scales to B5 if moon-centered. If iteration is required, the time tag for the state vector is in INTIME.

$\underline{V}_{iprime}$: Value of required velocity computed by Lambert routine (i.e. VVE$\underline{C}$ value when return from routine) at the time INTIME. Scale factor B7 (earth) or B5(moon), units meters/centi-second. Rescaled if moon-centered to B7 before exiting from "INITVEL7".

$\underline{V}_{pass1}$: Value of passive vehicle velocity vector, scale factor B7, units meters/centi-second (see $\underline{R}_{pass1}$).

$\underline{V}_{pass2}$: Value of passive vehicle velocity vector, scale factor B7, units meters/centi-second (see $\underline{R}_{pass2}$).

$\underline{V}_{pass3}$: Value of passive vehicle velocity vector at the start of the burn of interest (e.g. TPI burn), scale factor B7, units meters/centi-second (loaded in several cases in "PRECSET"). See $\underline{R}_{pass3}$.

$\underline{V}_{pass4}$: Value of passive vehicle velocity vector at intercept (T_{pass4}) time, scale factor B7, units meters/centi-second.

$\underline{V}_{pprec}$: Value of $\underline{V}_{pass3}$ at entrance to "S33/34.1", used to form a standard initial condition for performance of conic integration in "ADTIME+3", scale factor B7, units meters/centi-second (see $\underline{R}_{aprec}$).

$\underline{V}_{target}$: Value of active vehicle velocity at intercept (after doing the burn), scale factor B7(earth) or B5(moon), units meters/centi-second. If VTARGTAG is non-zero, value computed by precision integration in "INITVEL2"; if VTARGTAG is 0, value computed by "INITV" at the end of Lambert iteration.

$\underline{V}_{tprime}$: Value of $\underline{V}_{target}$ when return from "INITVEL" routine, scale factor B7, units meters/centi-second (rescaled from B5 if moon-centered in "INITVEL7").

VC$\underline{V}$: See Orbital Integration.

VTARGTAG: Single precision cell, scale factor B14, used to store the required number of Lambert iterations. Information originally set in push-down list location OD (called TS_1 in programmed equations), with a value of zero meaning that no iterations are required (hence $\underline{V}_{target}$ computed by "INITV" and target vector information, barring the effects of COZY4, remains unchanged).

VVE$\underline{C}$: See Conic Routines.

XXXALT: See Burn Control.

Return to Earth Computations

P37

Make restart group 4 inactive (P37 is not restart protected)

ECSTEER = 0.5

VPRED = 0

GAMMAEI = 0

$TS = 0633_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to previous line

$TS = 0660_{vn}$

Perform "GOFLASHR": if terminate, proceed to "GOTOPOOH"
if proceed, skip next two lines
otherwise, proceed to previous line

$TS = 001_2$ and perform "BLANKET" (R1BLNK)

End of job

RTEDVD = VPRED (overflow indicator reset here)

RTEGAM2D = GAMMAEI

CONICX1 = 2

$MAMAX1 = K_{c4rte}$

$T_{decl} = T_{ig}$

Perform "CSMPREC"

$\underline{R}_{t1} = \underline{R}_{att}$

$\underline{V}_{t1} = \underline{V}_{att}$

$T_1 = T_{att}$

If $X2 \neq 0$: (i.e. in lunar sphere)

$TS = 0612_8$

Perform "VARALARM"

$TS = 0509_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to previous line
otherwise, proceed

Proceed to "P37"

$CFPA = unit\underline{V}_{t1} \cdot unit\underline{R}_{t1}$

If $|CFPA| - K_{epc1} \geqslant 0$:

$T\underline{S} = unit\underline{Z}$

If $|CFPA| - K_{epc1} < 0$:

$T\underline{S} = unit\underline{R}_{t1} * unit\underline{V}_{t1}$

Set bit 14(RETROFLG) of FLAGWRD5 = 0

If $TS_z < 0$:

$T\underline{S} = - T\underline{S}$

Set bit 14(RETROFLG) of FLAGWRD5 = 1

$U\underline{H} = unit(T\underline{S} * unit\underline{R}_{t1})$

Set bit 13(SLOWFLG) of FLAGWRD5 = 0

If RTEDVD < 0:

RTEDVD = |RTEDVD|

If $|\underline{R}_{t1}| - K_{k1rte} \geqslant 0$:

Set bit 13(SLOWFLG) of FLAGWRD5 = 1

$MAMAX2 = K_{rtc0} + K_{rtc1} |\underline{R}_{t1}| + K_{rtc2}|\underline{R}_{t1}|^2 + K_{rtc3}|\underline{R}_{t1}|^3$

NN1A = -9

$RCON = K_{k2rte}$

If RTEGAM2D $\neq$ 0:

$XOFT2 = \left(\cos\left(\frac{1}{4} - RTEGAM2D\right)\right) / \left(\sin\left(\frac{1}{4} - RTEGAM2D\right)\right)$ $\left(\frac{1}{4} = 90^{\circ}\right)$

If RTEGAM2D = 0:

If $|\underline{R}_{t1}| - K_{k1rte} < 0$:

$XOFT2 = K_{k3rte}$

If $|\underline{R}_{t1}| - K_{k1rte} \geqslant 0$:

$XOFT2 = K_{k4rte}$

Proceed to "RTE360"

<u>RTE360</u>

Perform "V2T100"

If TS $\neq$ 0:

Perform "VARALARM" (TS already set to alarm pattern)

$TS = 0509_{vn}$

(If TS $\neq$ 0):

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to previous line
otherwise, proceed

Proceed to "P37"

$RVE\underline{C} = \underline{R}_{t1}$

RDESIRED = RCON

$VVE\underline{C} = \underline{V}_{2t1}$

Perform "TMRAD100"

$T_2 = T_1 + T_{12}$

If RTEGAM2D $\neq$ 0:

TS = XOFT2

If RTEGAM2D = 0:

$TS = K_{rtd1} + K_{rtd2}|\underline{V}_{t2}| + K_{rtd3}|\underline{V}_{t2}|^2 + K_{rtd4}|\underline{V}_{t2}|^3$

$TS = TS + C_{rted1}$

XOFT2ERR = TS - XOFT2

$ALPHA\underline{V} = \text{unit}\underline{R}_{t2}$

Perform "GETERAD"

$RCONPR = ERADM + K_{e3rte}$

If $|RCONPR - RCON| - K_{epc2} < 0$:

If $|XOFT2ERR| - K_{epc3} < 0$:

Proceed to "P37E"

TS = NN1A + 1 (Tag here is "RTE375")

If TS $\geq$ 0:

$TS = 0605_8$

Perform "VARALARM"

$TS = 0509_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to previous line
otherwise, proceed

Proceed to "P37"

NN1A = TS

If NN1A = -8:   (i.e. first pass)

TS = XOFT2ERR

If NN1A ≠ -8:

$$TS = XOFT2ERR \left(\frac{XOFT2PR - XOFT2}{XOFT2ERR - XOFT2ERP} \right)$$

RCON = RCONPR

If overflow has taken place, proceed to "RTE360" (indicator reset)

XOFT2ERP = XOFT2ERR

XOFT2PR = XOFT2

XOFT2 = XOFT2 + TS

Proceed to "RTE360"

<u>P37E</u>

Perform "RTEVN"

If RCON - PCON BETA1 > 0:

PHI2 = 1

If RCON - PCON BETA1 ≤ 0:

PHI2 = -1

Perform "PREC100"

If TS ≠ 0:

Perform "VARALARM"   (TS already set to alarm pattern)

$TS = 0509_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to previous line
otherwise, proceed

Proceed to "P37"

Perform "RTEVN"

OPTION1 = 7

OPTION2 = 1

$TS = 0406_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to previous line

If OPTION2 = 2: (RCS specified)

$TS_1 = 2\ K_{mdtrc}$

If bit 15(2JETSFLG) of FLAGWRD1 = 0:

$TS_1 = 2\ TS_1$

$TS = DV\ /\ K_{vcrcs}$

If OPTION2 $\neq$ 2: (SPS specified)

$TS_1 = C_{emdot}$

$TS = DV\ /\ K_{vcsps}$

$TS_2 = K_{p37e0} + K_{p37e1}\ TS + K_{p37e2}\ TS^2$

$T_{ig} = T_1 - K_{csubt}\ TS_2\ MASS\ /\ TS_1$ (correct single precision MASS used here)

$TS = 0633_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to previous line

VHFCNT = 0

TRKMKCNT = 0

Perform "INTSTALL"

$RC\underline{V} = \underline{R}_{t1}$

Set bit 4(CONICINT) of FLAGWRD3 = 1

$VC\underline{V} = \underline{V}_{2t1}$

$T_{et} = T_1$

$T_{decl} = T_2$

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

Perform "INTEGRVS"

$\underline{R}_{t2} = \underline{R}_{att}$

$T\underline{S}_r = \underline{R}_{att}$

X1 = - CONICX1

$T_2 = T_{att}$

$\underline{V}_{t2} = \underline{V}_{att}$

If $\left((K_{mcs7p5}\ \text{unit}\underline{R}_{t1} + K_{msn7p5}\ \underline{UH}) \cdot \text{unit}\underline{R}_{t2} \right) + K_{mcs22p5} < 0$:

Proceed to "P37W"

$TS = K_{th165}$

If $\underline{UH} \cdot \underline{R}_{t2} < 0$:

$TS = K_{th210}$

SNTH = sin TS

CSTH = cos TS

Set bit 9 (RVSW) of FLAGWRD7 = 0 (means new $\underline{R}$, $\underline{V}$ desired)

$RVE\underline{C} = \underline{R}_{t1}$

$VVE\underline{C} = \underline{V}_{2t1}$

Perform "TIMETHET" (writes over previous $T\underline{S}_r$)

Proceed to "P37W"

RTEVN

VNSTORE = Return address

$VPRED = |\underline{V}_{t2}|$

$T3TOT4 = T_2 - T_{ig}$

$GAMMAEI = \frac{1}{4} - \cos^{-1}(\text{unit}\underline{R}_{t2} \cdot \text{unit}\underline{V}_{t2})$ ($\frac{1}{4} = 90^\circ$)

$T\underline{S} = \underline{V}_{2t1} - \underline{V}_{t1}$

$DELVLV\underline{C} = (T\underline{S} \cdot U\underline{H},\ 0,\ -T\underline{S} \cdot \text{unit}\underline{R}_{t1})$

If bit 14(RETROFLG) of FLAGWRD5 = 1: (bit set in "P37")

$DELVLVC_x = -DELVLVC_x$

$VGDISP = |DELVLV\underline{C}|$

$RVE\underline{C} = \underline{R}_{t2}$

$RDESIRED = |RVE\underline{C}| - K_{304rt}$

$VVE\underline{C} = \underline{V}_{t2}$

Perform "TMRAD100"

$VTERM = |\underline{V}_{t2}|$

$GAMTERM = \left| \sin^{-1}(\text{unit}\underline{V}_{t2} \cdot \text{unit}\underline{R}_{t2}) \right|$

Perform "AUGEKUGL"

$TS = T_{ent} + T_{12} + T_2$

If $C_{p37range} \neq 0$:

  $PHIE = C_{p37range}$ Note that this does <u>not</u> affect T_{ent}

LNGSPL = sin PHIE   (used as temporary storage)

LATSPL = cos PHIE   (used as temporary storage)

$ALPHA\underline{V} = \text{unit}\left(\text{unit}\underline{R}_{t2} * \text{unit}\underline{V}_{t2} * \text{unit}\underline{R}_{t2}\right) \text{LNGSPL} + \text{unit}\underline{R}_{t2} \text{ LATSPL}$

Set bit 13(ERADCOMP) of FLAGWRD1 = 0

Set bit 12(LUNLATLO) of FLAGWRD3 = 0

Perform "LAT-LONG"   (time argument is TS above)

LATSPL = LAT

LNGSPL = LONG

$TS = 0661_{vn}$

Perform "GOFLASHR": if terminate, proceed to "GOTOPOOH"
if proceed, skip next 2 lines
otherwise, proceed to "P37"

$TS = 100_2$ and perform "BLANKET"   (R3BLNK)

End of job

$TS = 0639_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to "P37"

$TS = 0660_{vn}$

Perform "GOFLASHR": if terminate, proceed to "GOTOPOOH"
if proceed, skip next 2 lines
otherwise, proceed to "P37"

$TS = 001_2$ and perform "BLANKET"   (R1BLNK)

End of job

$TS = 0681_{vn}$

Proceed to "GOFLASH": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to "P37"

Proceed to address specified by VNSTORE

TMRAD100

Set bit 9(RVSW) of FLAGWRD7 = 0 (means new $\underline{R}$, $\underline{V}$ desired)

SGNRDOT = - 20000_8

X1 = - CONICX1

Perform "TIMERAD"

$\underline{V}_{t2} = T\underline{S}_v$

$\underline{R}_{t2} = T\underline{S}_r$

$T_{12} = T$

Return

PREC100 (This, from 6th line until "PREC175", is Final State Vector Computation)

SPRTEX = Return address

NN1A = 10

RD = RCON

DT21PR = +MAX

NN2 = -15

Perform "INTSTALL"

$RC\underline{V} = \underline{R}_{t1}$

Set bit 4(CONICINT) of FLAGWRD3 = 0

$VC\underline{V} = \underline{V}_{2t1}$

$T_{et} = T_1$

$T_{decl} = T_2$

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

Perform "INTEGRVS"

$\underline{R}_{t2} = \underline{R}_{att}$

X1 = - CONICX1

$T_2 = T_{att}$

$\underline{V}_{t2} = \underline{V}_{att}$

Proceed to "PREC125"

PREC125

$T\underline{S}_r = \underline{R}_{t2}$

$T\underline{S}_v = \underline{V}_{t2}$

Perform "PARAM"

PdRPRE = P

RdAPRE = RdA

RPRE = R1

XOFT2PRE = COGA

TS = | XOFT2 - XOFT2PRE | - K_{epc4}

If no overflow has taken place:

If TS < 0:

Proceed to "PREC175"

If NN2 $\geqslant$ 0:

TS = 0605_8

Proceed to address specified by SPRTEX

If NN1A = 0:

BETA4 = RD / RPRE (tag here "PREC162")

If NN1A $\neq$ 0:

TS = 1 - PdRPRE RdAPRE BETA1 (scale factor B4)

If TS < 0:

BETA4 = 1/ RdAPRE

If TS $\geqslant$ 0:

BETA4 = (PdRPRE BETA1) / (1 - $\sqrt{TS}$ PHI2)

BETA12 = 1 - BETA4

If BETA12 $\geq$ 0:

If XOFT2PRE $\geq$ 0:

BETA12 = - BETA12

If $|BETA12| - K_{epc6} < 0$:

Proceed to "PREC175"

RF = RPRE BETA4

NN2 = NN2 + 1 (Tag here is "PREC170")

$RVE\underline{C} = \underline{R}_{t2}$

Set bit 9(RVSW) of FLAGWRD7 = 1 (means new $\underline{R}$, $\underline{V}$ not desired)

$VVE\underline{C} = \underline{V}_{t2}$ sgn BETA12

SGNRDOT = - 20000_8 sgn BETA12

X1 = - CONICX1

RDESIRED = RF

Perform "TIMERAD"

DT21 = T sgn BETA12

TS = DT21 / DT21PR (scale factor B3)

If TS $\geq$ 0:

$TS_1 = 1.0$ (actually +MAX)

If TS < 0:

$TS_1 = - 0.6$

$TS_2 = TS / TS_1 - 1$ (scale factor B3)

If $TS_2 \geq 0$:

$DT21 = DT21PR \; TS_1$

DT21PR = DT21

Perform "INTSTALL"

Set bit 4(CONICINT) of FLAGWRD3 = 0

$\text{RC}\underline{V} = \underline{R}_{t2}$

$\text{VC}\underline{V} = \underline{V}_{t2}$

$T_{et} = T_2$

$T_{decl} = T_{et} + \text{DT21}$

Set bit 12 (MOONFLAG) of FLAGWRDO = 0

Perform "INTEGRVS"

$\underline{R}_{t2} = \underline{R}_{att}$

X1 = - CONICX1

$T_2 = T_{att}$

$\underline{V}_{t2} = \underline{V}_{att}$

Proceed to "PREC125"

PREC175

RERR = RPRE - RD

If $|\text{RERR}| - K_{epc7} < 0$:

If $|\text{XOFT2} - \text{XOFT2PRE}| - K_{epc8} < 0$:

TS = 0

Proceed to address specified by SPRTEX

$\text{TS} = 0613_8$

Proceed to address specified by SPRTEX

If NN1A = 0:

$\text{TS} = 0605_8$

Proceed to address specified by SPRTEX

If NN1A = 10:

$\text{RCON} = \text{RD}^2 / \text{RPRE}$

DRCON = RCON - RD

Proceed to "PREC210"

TS = DRCON / (RPREPR - RPRE) (scale factor B2)

$\text{TS}_1 = \text{TS} + 2$

If no overflow has taken place: (e.g. $TS_1 < 4$)

If $|TS_1| - 2 < 0$:

Skip next line

TS = - 4 (actually -MAX)

DRCON = TS RERR

RCON = RCON + DRCON

Proceed to "PREC210"

PREC210

RPREPR = RPRE

NN1A = NN1A - 1

Perform "V2T100"

If TS = 0, proceed to 4th line of "PREC100"

Proceed to address specified by SPRTEX (TS set to alarm pattern)

V2T100 (This is the CONICRETURN routine)

PD33 = Return address

If RCON $\geq$ 0:

If RCON $- |\underline{R}_{t1}| < 0$: (hence LAMBDA $\geq$ 1)

Skip next line

Proceed to "POODOO" (pattern 20610_8)

Set bit 5(F2RTE) of FLAGWRDO = 0

LAMBDA $= |\underline{R}_{t1}|$ / RCON

BETA1 = 1 + $XOFT2^2$

BETA5 = BETA1 LAMBDA

THETA1 = BETA5 LAMBDA - 1

THETA2 = $2 |\underline{R}_{t1}|$ (LAMBDA - 1)

THETA3 = $K_{rtmurt} / |\underline{R}_{t1}|$

$$TS = BETA5 \left(\frac{MAMAX1 - |\underline{R}_{t1}|}{MAMAX1 - RCON} \right) - 1, \text{ limited } < 2^{10} \text{ (overflow reset)}$$

If TS $\geq$ 0:

$TS_1 = \sqrt{TS}$

If TS < 0:

$TS_1 = 0$

XOFT1MIN = $- TS_1$

DXT1MAX = TS_1 / 16

$$TS = BETA5 \left(\frac{MAMAX2 - |R_{t1}|}{MAMAX2 - RCON} \right) - 1\text{, limited} < 2^{10} \quad \text{(overflow reset)}$$

If TS $\geq$ 0:

$TS_1 = \sqrt{TS}$

If TS < 0:

$TS_1 = 0$

XOFT1MAX = TS_1

If NN1A < 0: (i.e. not precision phase)

If RTEDVD = 0:

If CFPA $\geq$ 0:

Proceed to "V2T145"

Proceed to "V2T140"

BETA6 = (2 - LAMBDA) BETA5 - 1 (2 actually is +MAX)
(Tag here "V2T110")

XOFT1PRP = XOFT1

If BETA6 $\leq$ 0:

If PHI2 $\geq$ 0:

PHI2 = - PHI2

NN1A = 10

If XOFT1 > 0, proceed to "V2T145"

Proceed to "V2T140"

TS = $\sqrt{BETA6}$

If PHI2 $\geq$ 0:

XOFT1MAX = TS

XOFT1MIN = - TS

If XOFT1 > 0, proceed to "V2T145"

Proceed to "V2T140"

If XOFT1 > 0:

XOFT1MIN = TS

Proceed to "V2T145"

XOFT1MAX = - TS

Proceed to "V2T140"

<u>V2T140</u>

XOFT1 = XOFT1MIN

DXOFT1 = DXT1MAX

Proceed to "V2T150"

<u>V2T145</u>

XOFT1 = XOFT1MAX

DXOFT1 = - DXT1MAX

Proceed to "V2T150"

<u>V2T150</u>

Perform "GAMDV10"

If RTEDVD = 0:

TS = 0

Proceed to address specified by PD33

If RTEDVD - DV $\geq$ 0, proceed to "V2T175"

If NN1A $\geq$ 0, proceed to "V2T185" (i.e. precision phase)

If XOFT1 > 0:

TS = 0

Proceed to address specified by PD33

If CFPA ≤ 0:

TS = 0

Proceed to address specified by PD33

XOFT1 = XOFT1MAX

DXOFT1 = - DXT1MAX

Perform "GAMDV10"

If RTEDVD - DV < 0:

TS = 0

Proceed to address specified by PD33

Proceed to "V2T175"

<u>V2T175</u>

Set bit 5(F2RTE) of FLAGWRD0 = 1

If bit 13(SLOWFLG) of FLAGWRD5 = 0: (bit set in "P37")

XOFT1MAX = XOFT1

DXOFT1 = - DXT1MAX

If bit 13(SLOWFLG) of FLAGWRD5 = 1:

XOFT1MIN = XOFT1

DXOFT1 = DXT1MAX

Perform "GAMDV10"

If NN1A < 0: (i.e. not precision phase)

TS = 0

Proceed to address specified by PD33

Proceed to "V2T185"

<u>V2T185</u>

If |XOFT1 - XOFT1PRP| - 2 DXT1MAX < 0:

TS = 0

Proceed to address specified by PD33

XOFT1 = XOFT1PRP

If XOFT1 - XOFT1MAX $\geq$ 0:

XOFT1 = XOFT1MAX

Perform "DVCALC"

TS = 0

Proceed to address specified by PD33

If XOFT1 - XOFT1MIN $<$ 0:

XOFT1 = XOFT1MIN

Perform "DVCALC"

TS = 0

Proceed to address specified by PD33

GAMDV10 (This is XVITERATION routine)

Perform "DVCALC"

TS = XOFT1MAX - XOFT1MIN

If no overflow has taken place:

If TS - K_{epc9} $<$ 0, Return

If TS - DXT1MAX $<$ 0:

DXOFT1 = $\frac{1}{2}$ TS sgn DXOFT1

NN2 = - 144

Proceed to "GAMDV25"

GAMDV25

TS = NN2 + 1

If TS $\geq$ 0:

TS = 0605_8

Proceed to address specified by PD33

NN2 = TS

XOFT1PR = XOFT1

DVPR = DV

XOFT1 = XOFT1 + DXOFT1

Perform "DVCALC"

If bit 5(F2RTE) of FLAGWRDO = 1, proceed to "GAMDV35"

If DV - DVPR $\geq$ 0:

DXOFT1 = $-\frac{1}{2}$ DXOFT1

Proceed to "GAMDV50"

GAMDV35

TS = RTEDVD - DV

If $|TS| - K_{epc10} < 0$, Return

Reset overflow indicator

TS_1 = TS / (DV - DVPR)

DXOFT1 = (XOFT1 - XOFT1PR) TS_1

If overflow has taken place since indicator reset:

DXOFT1 = DXT1MAX sgn DXOFT1

Proceed to "GAMDV50"

If $|DXOFT1|$ - DXT1MAX $\geq$ 0:

DXOFT1 = DXT1MAX sgn DXOFT1

Proceed to "GAMDV50"

GAMDV50

BETA9 = XOFT1 + 1.1 DXOFT1

If BETA9 - XOFT1MAX $\geq$ 0:

DXOFT1 = $\frac{1}{2}$ (XOFT1MAX - XOFT1)

Proceed to "GAMDV65"

If BETA9 - XOFT1MIN $<$ 0:

DXOFT1 = $\frac{1}{2}$ (XOFT1MIN - XOFT1)

Proceed to "GAMDV65"

GAMDV65

If $|DXOFT1| - K_{epc9} < 0$, Return

Proceed to "GAMDV25"

DVCALC

$TS = THETA1 - XOFT1^2$ (subtraction done triple precision)

$PCON = THETA2 / TS$

$TS_1 = THETA3 \sqrt{PCON}$ (in 28D)

$\underline{V}_{2t1} = TS_1 \; XOFT1 \; unit\underline{R}_{t1} + TS_1 \; U\underline{H}$

$DV = |\underline{V}_{2t1} - \underline{V}_{t1}|$

Return

P37W

Set bit 8 (XDELVFLG) of FLAGWRD2 = 0

Set bit 10 (NORMSW) of FLAGWRD7 = 0

Set bit 6 (FINALFLG) of FLAGWRD2 = 1

$\underline{R}_{targ} = T\underline{S}_r$

$T_{pass4} = T + T_1$

$DELVEET\underline{3} = \underline{V}_{2t1} - \underline{V}_{t1}$

Perform "VN1645"

Proceed to previous line (if return due to V32E to F V16N45)

See also list of major variables and list of routines

ALPHAV: See Coordinate Transformations.

BETA1: Intermediate quantity computed near start of "V2T100", scale factor B1, equal to $(1 + XOFT2^2)$, i.e. reciprocal of square of sine of post-return flight path angle.

BETA4: Intermediate quantity computed in "PREC125", stored in push-down list, scale factor B1.

BETA5: Intermediate quantity computed near start of "V2T100", scale factor variable (1 + LAMBDA scale factor), stored in push-down list location 28D. Complement of LAMBDA scale factor is (X1 -1).

BETA6: Intermediate quantity computed in "V2T100", scale factor B17, stored in push-down list location 16D (as a triple precision quantity).

BETA9: Intermediate quantity computed in "GAMDV50", scale factor B5, stored in push-down list location 24D.

BETA12: Intermediate quantity computed in "PREC125", scale factor B1. Quantity in program is the complement of that in the equation documentation, so that its sign can also be used to reflect the equation function performed by ϕ_4, the "precision trajectory direction switch."

C_{emdot}: See Steering Computations.

$C_{p37range}$: Single precision erasable memory constant, program notation "P37RANGE", scale factor B0, units revolutions: multiply by 21600 to convert to nautical mile scale compatible with constants used in "AUGEKUGL". If non-zero, writes over PHIE in "RTEVN".

C_{rtedl}: Erasable memory (double precision) constant, program notation "RTED1", scale factor B3, giving the bias term value used in "RTE360" to compute desired "final cotangent of the flight path angle" (other terms use K_{rtdi} in fixed memory).

CFPA: Cosine of initial flight path angle (before application of any thrust), scale factor B1, computed near start of "P37".

COGA: See Conic Routines.

CONICX1: Single precision cell, scale factor B14, initialized to a value of 2 near start of "P37" and used to set index register X1 for proper interface with conic routines. X1 is set to - CONICX1, which is, of course, -2 (signifying to conic routines that selection of earth as central body is required).

CSTH: See Conic Routines.

DELVEET3: See Rendezvous Computations (used in "VN1645" for velocity increment information). Program notation also "DELVSIN".

DELVLVC: See Burn Control.

DRCON: "Change in the final radius of a conic trajectory," scale factor B29, units meters, used in iterator computation to obtain a new value for RCON.

DT21: Value of "adjustment" to T_2 in "PREC125" to obtained desired final radius, scale factor B28, units centi-seconds, stored in push-down list location 0D.

DT21PR: Value of previous DT21, same scaling, initialized to +MAX, i.e. $(2^{28} - 1)$ centi-seconds, near start of "PREC100".

DV: Magnitude of required velocity change at ignition time computed in "DVCALC", scale factor B7, units meters/centi-second.

DVPR: Value of previous DV loaded in "GAMDV25", same scaling, stored in push-down list location 20D.

DXOFT1: Value of change in XOFT1, scale factor B5, initialized in "V2T140" or "V2T145" and updated in "V2T150". Stored in push-down list location 16D. Updating actually in "GAMDV35" computation entered from "V2T150".

DXT1MAX: Value of maximum allowed change in DXOFT1, scale factor B5, stored in push-down list location 12D.

ECSTEER: See Burn Control.

ERADM: See Coordinate Transformations.

GAMMAEI: Flight path angle loaded and displayed in R3 of noun 60, scale factor B0, units revolutions. Used initially at start of "P37" to specify desired flight path angle (loaded into RTEGAM2D), and subsequently loaded in "RTEVN" with derived value of the angle for display purposes. See also Display Computations.

GAMTERM: See Display Computations.

K_{304rt}: Constant, program notation "30480RTE", scale factor B29, units meters. Value is 30480×2^{-29}, corresponding to 30480 meters or 100,000 feet.

K_{c4rte}: Constant, program notation "C4RTE", scale factor B30, value $-6.986643E7 \times 2^{-30}$, corresponding to -6.986643E7 meters. Used near start of "P37" to initialize MAMAX1.

K_{csubt}: Constant, program notation "CSUBT", scale factor B0, value 0.5.

K_{e3rte}: Constant, program notation "E3RTE", scale factor B29, units meters. Value is 121920×2^{-29}, corresponding to 121920 meters or 400,000 feet.

K_{epc1}: Constant, program notation "EPC1RTE", scale factor B1, value 0.99966×2^{-1}. Value corresponds to cosine 1.5°.

K_{epc2}: Constant, program notation "EPC2RTE", scale factor B29, units meters. Value is 100×2^{-29}, corresponding to 100 meters.

K_{epc3}: Constant, program notation "EPC3RTE", scale factor B0, value 0.001.

K_{epc4}: Constant, program notation "EPC4RTE", scale factor B0, value 0.00001.

K_{epc6}: Constant, program notation "EPC6RTE", scale factor B1, value 7E-6 x 2^{-1}, corresponding to 7E-6.

K_{epc7}: Constant, program notation "EPC7RTE", scale factor B29, value 1000 x 2^{-29}, corresponding to 1000 meters.

K_{epc8}: Constant, program notation "EPC8RTE", scale factor B0, value 0.002.

K_{epc9}: Constant, program notation "EPC9RTE", scale factor B5, value 1 x 2^{-25}. Corresponds to a "true value" of 2^{-20} (about 0.953674E-6).

K_{epc10}: Constant, program notation "EPC10RTE", scale factor B7, units meters/centi-second. Value is 0.0001 x 2^{-7}, corresponding to 0.01 meter/second.

K_{k1rte}: Constant, program notation "K1RTE", scale factor B29, units meters. Value is 7E6 x 2^{-29}, corresponding to 7E6 meters.

K_{k2rte}: Constant, program notation "K2RTE", scale factor B29, units meters. Value is 6,495,000 x 2^{-29}, corresponding to 6.495E6 meters, used in "P37" to initialize RCON. Value is 258 meters less than 400,000 feet above standard pad radius (of 6,373,338 meters).

K_{k3rte}: Constant, program notation "K3RTE", scale factor B0, value -0.06105, corresponding to sin (-3.5^{o}).

K_{k4rte}: Constant, program notation "K4RTE", scale factor B0, value -0.10453, corresponding to sin (-6.0^{o}).

K_{mcs7p5}: Constant, program notation "MCOS7.5", scale factor B0, value -0.99144486, corresponding to - cos 7.5^{o}.

$K_{mcs22p5}$: Constant, program notation "MCOS22.5", scale factor B2, value -0.92387953 x 2^{-2}, corresponding to - cos 22.5^{o}.

K_{mdtrc}: Constant, program notation "MDOTRCS", scale factor B3, units kilograms/centi-second, giving mass flow rate for single jet RCS (doubled for 2 jets, doubled again for 4 jets). Value is 0.0016375 x 2^{-3}, corresponding to 0.16375 kg/sec or about 0.361 pound/sec: this gives, multiplying by 276 (see K_{vcrcs}), thrust of about 99.6 lbs.

K_{msn7p5}: Constant, program notation "MSIN7.5", scale factor B0, value -0.13052619, corresponding to - sin 7.5^{o}.

K_{p37ei} (i = 0-2): Coefficients of power series expansion used in "P37E" to approximate $(1 - e^{-x})$. Coefficients imbedded in coding (due to calling sequence of polynomial routine), with first one at "P37T +5". Values are:

i	Scale Factor	Value Loaded
0	B3	$5.66240507E-4 \times 2^{-3}$
1	B1	$9.79487897E-1 \times 2^{-1}$
2	B-1	$-0.388281955 \times 2^{1}$

K_{rtci} (i = 0-3): Coefficients of power series expansion used in "P37" to compute required value of MAMAX2. Coefficients imbedded in coding (due to calling sequence of polynomial routine), with first one at "RTE320 -14". Values are:

i	Scale Factor	Value Loaded	Binary Equivalent
0	B31	$181{,}000{,}434 \times 2^{-31}$	181,000,432
1	B2	1.50785145×2^{-2}	1.5078514516
2	B-27	$-6.49993057E-9 \times 2^{27}$	-6.4999305660E-9
3	B-56	$9.76938926E-18 \times 2^{56}$	9.7693892759E-18

K_{rtdi} (i = 1-4): Coefficients of power series expansion used in "RTE360" to compute XOFT2ERR if RTEGAM2D = 0. Coefficients imbedded in coding (due to calling sequence of polynomial routine), with first one at "RTE369 +5". Values are (note velocity in meters/centi-second in program):

i	Scale Factor	Value Loaded
1	B3	0 (C_{rted1} is used for "bias" value)
2	B-4	$-4.8760771E-2 \times 2^{4}$
3	B-11	$4.5419476E-4 \times 2^{11}$
4	B-18	$-1.4317675E-6 \times 2^{18}$

K_{rtmurt}: Constant, program notation "RTMURTE", scale factor B18, value $199650.501 \times 2^{-18}$. Corresponds to the square root of about 3.98603225E10, roughly the earth μ in units of meters^3/centi-sec^2.

K_{th165}: Constant, program notation "THETA165", scale factor B0, units revolutions. Value is 0.458333333, corresponding to 165°.

K_{th210}: Constant, program notation "THETA210", scale factor B0, units revolutions. Value is 0.583333333, corresponding to 210°.

K_{vcrcs}: Constant, program notation "VCRCS", scale factor B5, units meters/centi-second, giving exhaust velocity for RCS. Value is 27.0664×2^{-5}, corresponding to 2706.64 meters/second (an I_{sp}, dividing by 9.80665, of 276.0 seconds).

K_{vcsps}: Constant, program notation "VCSPS", scale factor B5, units meters/centi-second, giving exhaust velocity for SPS. Value is 31.510396×2^{-5}, corresponding to an exhaust velocity of 3151.0396 meters/second. See K_{2vexh} in Steering Computations.

LAMBDA: Ratio of $|\underline{R}_{t1}|$/ RCON computed in "V2T100", scale factor given by (1 - X1), stored in push-down list location OD.

LAT, LONG: See Coordinate Transformations.

LATSPL: Value of predicted latitude of target computed in "RTEVN", scale factor BO, units revolutions. Also used in same routine for temporary storage of cos PHIE, scale factor B1.

LNGSPL: Value of predicted longitude of target computed in "RTEVN", scale factor BO, units revolutions. Also used in same routine for temporary storage of sin PHIE, scale factor B1.

MAMAX1: Value of "maximum allowable major axis of return trajectories with a negative radial component", scale factor B30, units meters. Initialized to K_{c4rte} near start of "P37".

MAMAX2: Value of "maximum allowable major axis of return trajectories with a positive radial component", scale factor B30, units meters. Computed as a polynomial function of $|\underline{R}_{t1}|$ in "P37".

MASS: See Digital Autopilot Interface Routines.

NN1A: Counter used to protect against excessive iterations in the computations, and also for computation control purposes. It is initialized to -9 in "P37" and incremented by 1 in "RTE360": when the increment causes the cell to be 0 (or positive), then alarm 0605_8 is generated. The negative sign is used as a flag that the conic portion of the computation is being executed. After completion of the conic displays, NN1A is set to +10 in "PREC100" and decremented by 1 in "PREC210". Scale factor of counter is B28.

NN2: Counter used to protect against excessive iterations in computations on loops internal to those protected by NN1A, scale factor B28. It is initialized to -144 in "GAMDV10" and incremented (with checks for reaching a 0 value) in "GAMDV25". It is also used in "PREC100", where initialized to -15 and subsequently incremented in "PREC125" to monitor for iterations to compute flight path angle.

OPTION1, OPTION2: See Display Interface Routines.

P: See Conic Routines.

PCON: Value of "semi-latus rectum of a conic trajectory" computed in "DVCALC", scale factor B28, units meters.

PD33: Single precision exit address from "V2T100", corresponding to push-down list location 33D.

PdRPRE: Value of P (ratio of semi-latus rectum to magnitude of $\underline{R}_{t2}$) loaded in "PREC125", scale factor B4, stored in push-down list location 26D.

PHI2: Indicator set to +1 to indicate a solution near apogee and to -1 to indicate a solution near perigee. Cell set near start of "P37E", with scale factor B2.

PHIE: See Display Computations.

$\underline{R}_{t1}$: Value of position vector at time "1" (i.e. time of ignition), scale factor B29, units meters. Loaded in "P37", with program notation "R(T1)/".

$\underline{R}_{t2}$: Value of position vector at time "2" (i.e. at final position for entry), scale factor B29, units meters. Program notation "R(T2)/".

$\underline{R}_{targ}$: See Rendezvous Computations.

R1: See Conic Routines.

RCON: Value of conic radius magnitude, scale factor B29, units meters. Initialized to K_{k2rte} in "P37", and updated in "PREC175" and "RTE360".

RCONPR: Value of radius magnitude computed in "RTE360" as K_{e3rte} above Fischer ellipse value, scale factor B29, units meters. Stored in push-down list address 2D.

RC$\underline{V}$: See Orbital Integration.

RD: Value of magnitude of final position vector desired, scale factor B29, units meters. Initialized in the beginning of "PREC100" to the final value of RCON resulting from the conic portion of the computation.

RdA: See Conic Routines.

RdAPRE: Value of RdA (ratio of magnitude of $\underline{R}_{t2}$ to semi-major axis) loaded in "PREC125", scale factor B6, stored in push-down list location 28D.

RDESIRED: See Conic Routines.

RERR: Error in magnitude of position vector computed at the start of "PREC175", scale factor B29, units meters, stored in push-down list.

RF: Value of "final radius" magnitude computed in "PREC125", scale factor B29, units meters, stored in push-down list.

RPRE: Value of R1 (magnitude of $\underline{R}_{t2}$) loaded at the start of "PREC125", scale factor B29, units meters. Stored in push-down list location 24D.

RPREPR: Value of previous RPRE, loaded in "PREC210", scale factor B29, units meters. Program notation "RPRE,".

RTEDVD: Value of desired velocity change loaded at the beginning of "P37" with the information loaded into R2 of N60, scale factor B7, units meters/centi-second. If a value of 0 is loaded, this means that a "minimum fuel" return computation is desired. Is R2 of N56.

RTEGAM2D: Value of desired flight path angle loaded at the beginning of "P37" with the information loaded into R3 of N60, scale factor B0, units revolutions. If a value of 0 is loaded, a polynomial is used in "RTE360" to compute desired XOFT2 data "to hit center of entry corridor" (polynomial is a function of $\underline{V}_{t2}$ magnitude). It can be accessed by R1 of N56.

RVE$\underline{C}$: See Conic Routines.

SGNRDOT: See Conic Routines.

SNTH: See Conic Routines.

SPRTEX: Single precision cell containing return address from "PREC100".

T: See Conic Routines.

T_1: Value of time tag associated with $\underline{R}_{t1}$ and $\underline{V}_{t1}$ loaded in "P37", scale factor B28, units centi-seconds.

T_2: Value of time tag associated with $\underline{R}_{t2}$ and $\underline{V}_{t2}$, scale factor B28, units centi-seconds. Also used for the desired time tag.

T_{12}: Value of transfer time computed by "TMRAD100" (i.e. T from "TIMERAD"), scale factor B28, units centi-seconds.

T_{ent}: See Display Computations.

T_{et}: See Orbital Integration.

T_{pass4}: See Burn Control.

T3TOT4: Transfer time displayed by N39, scale factor B28, units centi-seconds, giving time from ignition to arrival at entry interface.

THETA1: Intermediate quantity computed in "V2T100" and used in "DVCALC", scale factor B17, stored triple precision in push-down list location 2D.

THETA2: Intermediate quantity computed in "V2T100" and used in "DVCALC", scale factor B38, stored triple precision in push-down list location 5D.

THETA3: Intermediate quantity computed in "V2T100" and used in "DVCALC", scale factor B-4, stored in push-down list location 8D (double precision).

TRKMKCNT: See Measurement Incorporation (set 0 in "P37E" to permit the "VN1645"routine to have, with zeroing of VHFCNT, a 0 R3 display).

$\underline{UH}$: Unit "horizontal" vector computed in "P37", scale factor B1.

$\underline{V}_{2t1}$: Value of velocity at T_1 after addition of impulsive velocity increment, scale factor B7, units meters/centi-second. Loaded in "DVCALC". Program notation "V2(T1)/".

$\underline{V}_{t1}$: Value of velocity at T_1 before addition of impulsive velocity increment, scale factor B7, units meters/centi-second. Loaded in "P37", with program notation "V(T1)/".

$\underline{V}_{t2}$: Value of velocity at T_2, scale factor B7, units meters/centi-second. Program notation "V(T2)/".

VC$\underline{V}$: See Orbital Integration.

VGDISP: See Burn Control.

VHFCNT: See Measurement Incorporation (and comment above on TRKMKCNT).

VNSTORE: Single precision cell containing return address from "RTEVN".

VPRED: Velocity information loaded and displayed in R2 of noun 60, scale factor B7, units meters/centi-second. Used initially at start of "P37" to specify desired velocity increment (see RTEDVD), and subsequently loaded in "RTEVN" with derived value of velocity at entry interface altitude (i.e. magnitude of $\underline{V}_{t2}$). See Display Comp.

VTERM: See Display Computations.

VVE$\underline{C}$: See Conic Routines.

XOFT1: "Cotangent of the post-return flight path angle", scale factor B5 (i.e. flight path angle after application of impulsive velocity).

XOFT1MAX: Upper bound on the value of XOFT1, scale factor B5, stored in push-down list location 14D.

XOFT1MIN: Lower bound on the value of XOFT1, scale factor B5, stored in push-down list location 10D.

XOFT1PR: Value of previous XOFT1 loaded in "GAMDV25", scale factor B5, used in iterator. Stored in push-down list location 18D.

XOFT1PRP: Value of XOFT1 stored in "V2T100" (before entrance to "GAMDV10" iteration), scale factor B5. Stored in push-down list location 0D.

XOFT2: "Final cotangent of the flight path angle", scale factor B0. If RTEGAM2D non-zero, initialized in "P37" to cot ($\frac{1}{4}$ - RTEGAM2D), where "$\frac{1}{4}$", of course, since angles in revolutions, corresponds to 90°. Program notation "X(T2)".

XOFT2ERP: Value of previous XOFT2ERR, scale factor B0, loaded in "RTE360". Tag for cell is "DRCON", since same cell used later for that purpose.

XOFT2ERR: Value of error in flight path angle (0 if RTEGAM2D non-zero), scale factor B0 (cotangent of the angle is used, i.e. XOFT2 information). Stored in push-down list location 0D.

XOFT2PR: Value of previous XOFT2 loaded in "RTE360", scale factor B0. Tag for cell is "RPRE," (i.e. same cell as used subsequently for RPREPR).

XOFT2PRE: Value of "final cotangent of flight path angle for precision trajectory", scale factor B0, set to COGA in "PREC125".

S40.1 Entered from "P40S/F" (in P40/P41)

Set bit 7(FIRSTFLG) of FLAGWRD2 = 1

$\underline{BDT} = 0$

If bit 8(XDELVFLG) of FLAGWRD2 = 0:

Proceed to "S40.1B"

$DELVSAB = |\underline{DELVSIN}|$

$\underline{V}_{init} = \underline{V}_{tig}$

$\underline{TS}_1 = unit(\underline{V}_{tig} * \underline{R}_{tig})$ (stored in $\underline{UT}$ cell)

$\underline{R}_{init} = \underline{R}_{tig}$

$TS = K_{thetcon} \left|(\underline{V}_{tig} * \underline{R}_{tig})\right|$ (rounded multiplication, least increment in result 2^{16} m/cs)

$BURNANG = TS \; DELVSAB \; MASS_{dp} / (CAPF \left|\underline{R}_{tig}\right|^2)$

$\underline{TS}_2 = (\underline{DELVSIN} \cdot \underline{TS}_1) \; \underline{TS}_1$

$\underline{TS}_3 = \underline{DELVSIN} - \underline{TS}_2$ (in-plane component of specified velocity)

$\underline{V}_{gtig} = \underline{TS}_2 + \left|\underline{TS}_3\right| \left(unit(\underline{TS}_3 * \underline{TS}_1) \sin BURNANG + unit\underline{TS}_3 \cos BURNANG\right)$

$\underline{UT} = unit\underline{V}_{gtig}$

$\underline{TS} = \underline{V}_{gtig}$

Perform "GET.LVC"

Proceed to "S40.2,3"

S40.1B

$T_{decl} = T_{ig} - K_{twodt}$

$DELLT4 = T_{pass4} - T_{decl}$

Perform "AGAIN"

$\underline{TS}_4 = \underline{V}_{iprime}$ (stored in $\underline{UT}$ cell)

$T_{decl} = T_{ig}$

$DELLT4 = T_{pass4} - T_{decl}$

Perform "AGAIN"

$\underline{V}_{gtig} = DELVEET\underline{3}$

$\underline{TS} = \underline{V}_{gtig}$

Perform "GET.LVC"

$\underline{TS} = \underline{R}_{tig}$

Perform "CALCGRAV"

$\underline{TS} = CSTEER\left((\underline{V}_{iprime} - \underline{TS}_4)/K_{200cs} - GDT\underline{1} / K_{200cs}\right)$

$QFC\underline{T} = \underline{TS} - (\text{unit}\underline{V}_{gtig} \cdot \underline{TS})\ \text{unit}\underline{V}_{gtig}$

$TS_1 = CAPF / MASS_{dp}$

$U\underline{T} = \text{unit}\left(QFC\underline{T} + \sqrt{TS_1^{\,2} - |QFC\underline{T}|^2}\ \text{unit}\underline{V}_{gtig}\right)$

Proceed to "S40.2,3"

AGAIN

Perform "CSMPREC"

RTX2 = X2

RTX1 = X1

$\underline{R}_{tig} = \underline{R}_{att}$

$\underline{R}_{init} = \underline{R}_{att}$

$\underline{V}_{tig} = \underline{V}_{att}$

$\underline{V}_{init} = \underline{V}_{att}$

$TS_1 = 0$

$TS_2 = K_{eps45}$

If bit 10(NORMSW) of FLAGWRD7 = 0:

$TS_2 = K_{eps10}$

Perform "INITVEL"

Return

S40.2,3 Entered for P40/P41 from "S40.1"and "S40.1B"

$POINTVS\underline{M} = [REFSMMAT]\ U\underline{T}$

If bit 11(RCSBURN) of FLAGWRD1 = 1:

Proceed to "S40.2,3B"

$YAWANG = K_{trims}\ YACTOFF + K_{ybias}$

$PITANG = K_{trims}\ PACTOFF + K_{pbias}$

$\underline{X}_{smd}$ = (cos PITANG cos YAWANG, - cos PITANG sin YAWANG, sin PITANG)

$\underline{Z}_{smd}$ = (- sin PITANG cos YAWANG, sin PITANG sin YAWANG, cos PITANG)

$\underline{Y}_{smd}$ = (sin YAWANG, cos YAWANG, 0) **Note x,z,y sequence & use below.**

SCAXI$\underline{S}$ = (cos PITANG cos YAWANG, sin YAWANG, - sin PITANG cos YAWANG)

$T\underline{S}_1 = U\underline{T}$

$T\underline{S} = -\ unit\underline{R}_{tig} * U\underline{T}$

$T\underline{S}_2 = unitT\underline{S}$

If $|T\underline{S}| < K_{minmag}$:

$$T\underline{S}_2 = -\ unit\left((unit\underline{R}_{tig} + 0.125\ unit\underline{V}_{tig}) * U\underline{T} \right)$$

$T\underline{S}_3 = -\ T\underline{S}_2 * T\underline{S}_1$

$$[TS] = \begin{bmatrix} T\underline{S}_1 \\ T\underline{S}_2 \\ T\underline{S}_3 \end{bmatrix}$$

$\underline{X}_{smd} = \underline{X}_{smd}\ [TS]$

$\underline{Y}_{smd} = \underline{Y}_{smd}\ [TS]$

$\underline{Z}_{smd} = \underline{Z}_{smd}\ [TS]$

Proceed to "P40SXTY"

S40.2.3B

SCAXI$\underline{S}$ = unit$\underline{X}$

$\underline{X}_{smd} = U\underline{T}$

$T\underline{S} = U\underline{T} * \underline{R}_{tig}$

$T\underline{S}_2 = unitT\underline{S}$

If $|T\underline{S}| < K_{minmagr}$:

$$T\underline{S}_2 = -\ unit\left((unit\underline{R}_{tig} + 0.125\ unit\underline{V}_{tig}) * U\underline{T} \right)$$

$\underline{Y}_{smd} = T\underline{S}_2$

$\underline{Z}_{smd} = -(\underline{Y}_{smd} * \underline{X}_{smd})$

Proceed to "P40SXTY"

UPDATEVG Entered from "CALCN85" and "S40.8"

If bit 8(XDELVFLG) of FLAGWRD2 = 0:

If NBRCYCLS < 0: (set negative as initial condition and at end of "S40.9")

Proceed to "SETUP.9"

$\text{DELVSU}\underline{M} = \text{DELVSU}\underline{M} + \text{DELVRE}\underline{F}$

NBRCYCLP = NBRCYCLS + 1

NBRCYCLS = NBRCYCLP

Proceed to "VGCOMP"

VGCOMP

$\underline{V}_g = \underline{V}_{gtig} + \text{BD}\underline{T} - \text{DELVRE}\underline{F}$ ($\underline{V}_{gtig}$ notation also "VGPREV")

$\text{VGDISP} = |\underline{V}_g|$

$\underline{V}_{gtig} = \underline{V}_g$

Return (to caller of "UPDATEVG")

SETUP.9

If bit 7(FIRSTFLG) of FLAGWRD2 = 0:

$\underline{V}_{gtig} = \text{DELVEET}\underline{3} + \text{NBRCYCLP BD}\underline{T} - \text{DELVSU}\underline{M}$ ($\underline{V}_{gtig}$ also has notation "VGPREV"; DELVEET3 also "VGTEMP")

Establish "S40.9" (priority 10_8) (Restart protect by group 1.5, see "REDO40.9")

$\underline{R}_{init} = \underline{R}$

$\underline{V}_{init} = \underline{V}$

$T_{nit} = T_{pptm}$

$\text{DELLT4} = T_{pass4} - T_{nit}$

$\text{DELVSU}\underline{M} = 0$

NBRCYCLS = 0

NBRCYCLP = 0

Proceed to "VGCOMP"

S40.8 Entered due to AVEGEXIT setting in "P40SXTY"

Perform "UPDATEVG"

MASSTMP = CSMMASS

If($|\underline{DELVREF}| - C_{dvthresh}) < 0$:

If bit 11(STEERSW) of FLAGWRD2 = 0: (Tag here "LOTHRUST")

Proceed to "SERVXT1"

If bit 6(IDLEFAIL) of FLAGWRD1 = 1: (set/reset by "V97P")

Proceed to "SERVXT1"

$\underline{OMEGAC} = 0$

REPFRAC = -0

NVWORD1 = -0 (causes "CLOCKJOB" to generate V97 display)

Set bit 11(STEERSW) of FLAGWRD2 = 0

Proceed to "SERVEXIT"

CSMMASS = MASSTMP - C_{emdot} $K_{2secnds}$

If bit 11(STEERSW) of FLAGWRD2 = 0:

Proceed to "SERVXT1"

If bit 15(SWTOVER) of FLAGWRD9 = 1: (Tag here "CGTRACK")

REPFRAC = $K_{frepfrac}$

Skip next 2 lines

j = (bit 14 of DAPDATR1) (1 for LM on, 0 for LM off)

REPFRAC = $C_{erepfrac_j}$

$T\underline{S}_1 = BD\underline{T} - DELVRE\underline{F}$ (Tag here "TGOCALC")

$TS_2 = \text{unit}T\underline{S}_1 \cdot \underline{V}_g$

If $TS_2 \geq 0$:

Perform "ALARM" (pattern 1407_8) (Tag here "INCRSVG")

Proceed to "SERVEXIT"

$T_{go} = K_{mfourdt}\ TS_2\ (1 + TS_2 / K_{2vexh}) / (|\underline{TS}_1|) - C_{tdecay}$

$T_{ig} = T_{pptm} + T_{go}$ (for e.g. "CLOKTASK", giving GET of cutoff)

If $(T_{go} - K_{foursec}) < 0$:

Proceed to "S40.81"

$DELTA\underline{M} = CSTEER\ BD\underline{T} - DELVRE\underline{F}$

$T\underline{S} = [REFSMMAT]\ (unit\underline{V}_g * unitDELTA\underline{M})$

Perform "*SMNB*"

$OMEGA\underline{C} = KPRIMEDT\ T\underline{S}$

Proceed to "SERVXT1"

S40.9 (Established if a Lambert burn by "SETUP.9")

$TS_1 = 0$

$TS_2 = K_{ep45}$

If bit 10(NORMSW) of FLAGWRD7 = 0:

$TS_2 = K_{ep10}$

Set bit 2(GUESSSW) of FLAGWRD1 = 0

Perform "INITVEL" (starting at second line) See "REDO40.9" for restarts.

If bit 7(FIRSTFLG) of FLAGWRD2 = 0: (set 1 in "S40.1")

$BD\underline{T} = (\underline{V}_{iprime} - \underline{V}_{rprev}) \left(K_{200cs} / (T_{nit} - T_{nitprev}) \right) - GD\underline{T}$

If RTX2 $\leq$ 0: (means earth-centered computations)

$DELVEET\underline{3} = DELVEET\underline{3} + K_{earthmu}\ (T_{pptm} - NOMTIG)\ GOB\underline{L} / |\underline{R}|^2$

(DELVEET3 tag "VGTEMP")

$T_{nitprev} = T_{nit}$

$\underline{V}_{rprev} = \underline{V}_{iprime}$

Set bit 7(FIRSTFLG) of FLAGWRD2 = 0

NBRCYCLS = -1

End of job

RED040.9 Entered if a restart encountered from time of establishing "S40.9" in "SETUP.9" until return from "INITVEL" in "S40.9", due to restart group 1.5

DELVSUM = 0

NBRCYCLP = 0

DELVEET3 = $\underline{V}_{gtig}$ (for "SETUP.9"restoration)

NBRCYCLS = -1

End of job

S40.13 Established by "TIG-5" and "V97E"

TS_1 = VGDISP

If bit 7(+X translation complement) of channel 31 = 0:

$TS = K_{2rcsf} / MASS_{dp}$

If bit 15(2JETSFLG) of FLAGWRD1 = 0:

TS = 2 TS (i.e. 4-jet translation)

$TS_1 = TS_1 - TS$

$TS_2 = MASS_{dp}\ TS_1\ (1 - TS_1 / K_{2vexh})$

If $|TS_2| \geqslant 2^{14}$: (or other overflow)

End of job

$TS_3 = K_{100bm14}\ (TS_2 - C_{eimplsec}) / C_{efimpl6}$ (B14, PD2D)

If $(TS_3 - K_{500bm14}) \geqslant 0$:

End of job

If $TS_3 < 0$:

$TS_3 = C_{efimpl6}\ TS_3 / C_{efimp01}$ (B14)

Set bit 9(IMPULSW) of FLAGWRD2 = 1

Force sign agreement of TS_3

$T_{go} = (TS_3 + K_{100bm14})$, rescaled to scale factor B28

End of job

S41.1

Perform "CDUTRIG"

$\underline{TS} = \left[REFSMMAT \right] \underline{TS}$

Perform "*SMNB*"

$\underline{TS} = K_{tenb4} \left[QUADROT \right] \underline{TS}$ (now in control coordinates)

Return

See also list of major variables and list of routines

BDT: "Effect of rate of change of required velocity, and gravity, acting during the two-second computing interval, upon velocity-to-be-gained," scale factor B7, units meters/centi-second. Set 0 in "S40.1".

BURNANG: Value of one-half the central angle estimated to be traveled during the External Delta-V burn, scale factor B0, units revolutions, stored in push-down location 14D.

$C_{dvthresh}$: Single precision erasable memory constant, program notation "DVTHRESH", scale factor B-2, units meters/centi-second, giving velocity gate used in "S40.8" for concluding that engine failure has taken place. Program shifts constant right 9 places before use, to scale it B7 meters/centi-second (double precision). In order to avoid improper performance, constant should exceed the velocity increment obtained by ullage (in a 2-second interval).

$C_{eimplsec}$: Single precision erasable memory constant, program notation "EIMP1SEC", scale factor B14, units kilogram-meters/centi-second. When divided by mass of vehicle, would give the SPS impulse velocity acquired in the first second of burn. For a value in pound-seconds, PSEC, the fraction in the cell may be computed as PSEC x 10^{-2} x 9.80665 x 0.45359237 x 2^{-14}, where first term is value, second converts to centi-seconds, third is g, fourth converts from pounds to kilograms, and fifth is scale factor. Constant is used double precision, with least significant half the cell used for $C_{efimp01}$.

$C_{efimp01}$: Single precision erasable memory constant, program notation "EFIMP01", scale factor B14, units kilogram-meters/centi-second. It gives the slope of the SPS impulse curve from 0 to 1 second. For a value in pound-seconds/second, PNDSSC, the fraction in the cell may be computed as PNDSSC x 10^{-2} x 9.80665 x 0.45359237 x 2^{-14}, where first term is value, second converts to centi-seconds, third is g, fourth converts from pounds to kilograms, and fifth is scale factor. Constant is used double precision, with least significant half the cell used for $C_{efimp16}$.

$C_{efimp16}$: Single precision erasable memory constant, program notation "EFIMP16", scale factor B14, units kilogram-meters/centi-second. It gives the slope of the SPS impulse curve from 1 to 6 seconds (and may be computed by the formula given for $C_{efimp01}$ above). The constant is used double precision, with least significant half the cell used for $C_{e3j22r2m}$ (see Orbital Integration). Is equivalent to thrust, of course.

C_{emdot}: Single precision erasable memory constant, program notation "EMDOT", scale factor B3, units kilograms/centi-second, giving the nominal mass flow rate for the SPS engine.

$C_{erepfrac_j}$: See Digital Autopilot TVC Routines.

C_{tdecay}: Single precision erasable memory constant, program notation "ETDECAY", scale factor B14, units centi-seconds, giving value of thrust decay time (i.e. equivalent full-thrust time). It is subtracted from the "raw" time-to-go, and therefore should be a positive number in the memory. Used in "S40.8" only (for SPS burns).

CAPF: See Burn Control.

CSMMASS: See Digital Autopilot Interface Routines.

CSTEER: Scalar in cross-product steering law, scale factor B2. It is set to ECSTEER in "P40CSM"(provided a Lambert burn specified), and otherwise has most significant half zero. Least significant half is always zero.

DAPDATR1: See Digital Autopilot Interface Routines.

DELLT4: See Rendezvous Computations.

DELTA$\underline{M}$: Value of (CSTEER BD$\underline{T}$ - DELVRE$\underline{F}$), scale factor B7, units meters/centi-second. Its unit vector (scale factor B1) is stored temporarily in the push-down list.

DELVEET$\underline{3}$: See Rendezvous Computations (DELVSI$\underline{N}$ occupies the same cells).

DELVRE$\underline{F}$: See General Program Control.

DELVSAB: Absolute value of DELVSI$\underline{N}$ used in "S40.1" in the computation of BURNANG for External Delta-V burns, scale factor B7, units meters/centi-second.

DELVSI$\underline{N}$: See Burn Control.

DELVSU$\underline{M}$: Value of sum of DELVRE$\underline{F}$ outputs from Average-G computed in "UPDATEVG" for Lambert burn, used to correct $\underline{V}_{gtig}$ for accelerometer-output velocity gained since "S40.9" established. Scale factor B7, units meters/centi-second. Initialized to 0 in "SETUP.9".

GD$\underline{T}$, GDT$\underline{1}$: See General Program Control.

GOB$\underline{L}$: See General Program Control.

$K_{100bm14}$: Constant, program notation "100B-14", scale factor B14, units centi-seconds. Value is 100×2^{-14}, corresponding to one second.

K_{200cs}: Constant, program notation "200CS", scale factor B12, units centi-seconds. Value is 200×2^{-12}, corresponding to 2 seconds.

$K_{500bm14}$: Constant, program notation "500B-14", scale factor B14, units centi-seconds. Value is 500×2^{-14}, corresponding to 5 seconds.

K_{2rcsf}: Constant, program notation "S40.135", scale factor B23, nominal value 69.6005183 x 2^{-23}. Value corresponds to 796 K_{frcs2} times 2^{-23}, i.e. the velocity increment (after dividing by MASS) for 7.96 seconds of two-jet RCS thrusting. See Burn Control for K_{frcs2} value. Octal value is 00000_8 04263_8, corresponding to 69.59375 x 2^{-23}. Before original ignition, "S40.13" is entered 5 seconds before ignition time, with last Average-G sample made 5.96 seconds before ignition. Program zeros channel 5 (ullage jets) at end of "IGNITION" routine, 2 seconds after ignition.

$K_{2secnds}$: Constant, program notation "FOURSEC +1", scale factor B13, units centi-seconds. Octal value is 00620_8 00000_8, corresponding to 200 x 2^{-13}, or two seconds.

K_{2vexh}: Constant, program notation "2VEXHUST", scale factor B7, units meters/centi-second. Value is 63.020792 x 2^{-7}, corresponding to 2 x 31.510396 x 2^{-7}, where first term is an equation factor of two, second is the exhaust velocity in meters/centi-second, and the third is the scale factor. Exhaust velocity of 3151.0396 meters/second (10338.05643 fps) corresponds to an I_{sp}, dividing by 9.80665, of about 321.32 seconds, or 20500/63.8.

$K_{earthmu}$: Constant, program notation "EARTHMU", scale factor B36, value -3.986032E10 x 2^{-36}, corresponding to earth $-\mu$ (in units of meters^3/centi-second^2).

K_{ep10}: Constant, program notation "EP4(10)L", scale factor B0, units revolutions. Value is 0.027777777, corresponding to ten degrees.

K_{ep45}: Constant, program notation "EP4(45)L", scale factor B0, units revolutions. Value is 0.125, corresponding to 45 degrees.

K_{eps10}: Constant, program notation "EP4(10)H", scale factor B0, units revolutions. Value is 0.027777777, the same as K_{ep10} (duplicate storage in "high" part of memory).

K_{eps45}: Constant, program notation "EP4(45)H", scale factor B0, units revolutions. Value is 0.125, the same as K_{ep45}.

$K_{foursec}$: Constant, program notation "FOURSEC", scale factor B28, units centi-seconds. Value is 400 x 2^{-28}, corresponding to four seconds.

$K_{frepfrac}$: See Digital Autopilot TVC Routines.

$K_{mfourdt}$: Constant, program notation "-FOURDT", scale factor B16, units centi-seconds. Value is -800 x 2^{-18}, corresponding to (-1) x 200 x 2^{-16}, where first term is an equation factor, second is computing interval (i.e. 2 seconds), and third is scale factor.

K_{minmag}: See Attitude Maneuvers (equivalent effect achieved to use of explicit constant, by checking most significant half of magnitude for 0).

$K_{minmagr}$: Dummy constant used to show effect of checking for magnitude of vector information, scale factor B30, units meters. Value is equivalent to 2^{-14} (cf. K_{minmag}), or 2^{16} meters.

K_{pbias}: Constant, program notation "PBIAS", scale factor B0, units revolutions. Value is -0.00597222222, corresponding to -2.15 degrees (the "pitch mechanical bias with thrust on"). Hence a PACTOFF input of +2.15 degrees would be considered to line up the bell in pitch along +X.

K_{tenb4}: Constant, program notation "TENBNK14", scale factor B4, value 10×2^{-4}, corresponding to 10. Used to correct for the fact that matrix elements of [QUADROT] are multiplied by 0.1 because of the cycle rate during Attitude Maneuvers.

$K_{thetcon}$: Constant, program notation "THETACON", scale factor B6, value 0.31830989×2^{-8}. Value corresponds to $\frac{1}{2} \times (1/2\pi) \times 2^{-6}$, where first term is an equation factor of one-half (to obtain half the central angle traveled during the burn), second converts from radians to revolutions, and third is scale factor.

K_{trims}: Constant, program notation "TRIMSCAL", scale factor B-13, value 1.07975111×2^{-1}. Value corresponds to $85.41 \times 1/(360 \times 3600) \times 2^{13}$, where first term is bit weight in arc seconds for PACTOFF and YACTOFF, second converts to revolutions, and third is scale factor.

K_{twodt}: Constant, program notation "TWODT", scale factor B28, units centi-seconds. Value is 200×2^{-28}, corresponding to 2 seconds.

K_{ybias}: Constant, program notation "YBIAS", scale factor B0, units revolutions. Value is +0.00263888889, corresponding to +0.95 degrees (the "yaw mechanical bias with thrust on"). Hence a YACTOFF input of -0.95 degrees would be considered to line up the bell in yaw along +X.

KPRIMEDT: See Digital Autopilot TVC Routines.

MASS: See Digital Autopilot Interface Routines. Incorrect "double precision".

MASSTMP: Temporary storage for CSMMASS in "S40.8", scale factor B16, units kilograms, used to achieve restart protection there.

NBRCYCLP: Single precision counter, scale factor B14, of the number of cycles of DELVREF information that have been summed in DELVSUM. It is incremented in "UPDATEVG" and reset in "SETUP.9". It is used for restart protection purposes (with NBRCYCLS, which is in the preceding cell), and also to update $\underline{V}_{gtig}$ by the suitable amount of BDT for the time elapsed since "S40.9" was established.

NBRCYCLS: Single precision counter, scale factor B14, used in conjunction with NBRCYCLP. At the end of "S40.9", it is set to -1 as a flag to "UPDATEVG" that a new Lambert solution has been obtained. It is also set to an initial condition of -1 in "P40SXTY" (for P40 and P41) before Average-G is started.

NOMTIG: See Burn Control.

NVWORD1: See Burn Control.

OMEGA$\underline{C}$: See Digital Autopilot TVC Routines.

PACTOFF: See Digital Autopilot TVC Routines.

PITANG: Value of angle in pitch axis used in "S40.2,3", scale factor B0, units revolutions. Used to calculate the desired position of the engine bell in spacecraft coordinates.

POINTVS$\underline{M}$: See Attitude Maneuvers.

QFC$\underline{T}$: Value of quantity computed in "S40.1B", scale factor B-5, units meters/centi-second^2, stored in push-down list location 12D.

[QUADROT]: See Attitude Maneuvers.

$\underline{R}_{init}$: See Rendezvous Computations.

$\underline{R}_{tig}$: See Burn Control.

REPFRAC: See Digital Autopilot TVC Routines.

RTX1, RTX2: See Orbital Integration.

SCAXI$\underline{S}$: See Attitude Maneuvers.

T_{go}: Value of time-to-go computed in "S40.8", scale factor B28, units centi-seconds. Least significant half loaded with required delay before cutoff (for restart protection purposes) in "S40.81", scale factor B14.

T_{nit}: Value of time tag associated with state vector loaded by "SETUP.9", scale factor B28, units centi-seconds.

$T_{nitprev}$: Value of T_{nit} for previous entry into "S40.9", loaded at the end of "S40.9", scale factor B28, units centi-seconds. Used with T_{nit} to determine the proper divisor (with K_{200cs}) for difference of required velocities, in computation of BD$\underline{T}$. Since accelerometer sampling at 2 second intervals, value used to divide velocity difference would be expected to be an integer (e.g. 2 if four seconds elapsed). Time difference shifted left 17 places after being formed, giving result modulo 2^{11} centi-seconds (20.48 seconds).

T_{pass4}: See Burn Control.

$U\underline{T}$: Unit vector, scale factor B1, in the direction of desired thrust (expressed in reference coordinates). Cell also used for temporary storage purposes.

$\underline{V}_g$: Velocity-to-be-gained vector, scale factor B7, units meters/centi-second, in reference coordinates.

$\underline{V}_{gtig}$: See Burn Control (during Average-G running, retains the previous value of $\underline{V}_g$).

$\underline{V}_{init}$: See Rendezvous Computations.

$\underline{V}_{iprime}$: See Rendezvous Computations.

$\underline{V}_{rprev}$: Value of previous $\underline{V}_{iprime}$ (i.e. the one associated with $T_{nitprev}$), scale factor B7, units meters/centi-second.

$\underline{V}_{tig}$: See Burn Control.

VGDISP: See Burn Control.

$\underline{X}_{smd}$, $\underline{Y}_{smd}$, $\underline{Z}_{smd}$: See Inflight Alignment. Program notation also $[X_{scref}]$.

YACTOFF: See Digital Autopilot TVC Routines.

YAWANG: Value of angle in yaw axis used in "S40.2,3", scale factor B0, units revolutions. Cf. PITANG.

Telemetry

DODOWNTM Entered after receipt of program interrupt #8, telemetry end pulse (from telemetry system)

If bit 7(Word Order Code) of channel 13 = 0:

Perform "C13STALL"

Set bit 7(Word Order Code) of channel 13 = 1

Proceed to address specified by DNTMGOTO

DNPHASE1 Initial condition set in "STARTSUB" for DNTMGOTO

SUBLIST = -1

DNECADR = -1

DNTMGOTO = "DNPHASE2"

CTLIST = $K_{dntable_{DNLSTCOD}}$ (Tag here is "NEWLIST")

Perform "C13STALL"

Set bit 7(Word Order Code) of channel 13 = 0

Channel 34 = - DNLSTCOD

Channel 35 = 77340_8 (i.e. - 00437_8)

Resume

DNPHASE2

If DNECADR > 0: (i.e. sending data)

Proceed to "FETCH2WD"

If SUBLIST > 0: (i.e. sending sublist)

Proceed to "NEXTINSL"

If CTLIST ≤ 0: (End of list reached, start over)

Proceed to 4th line of "DNPHASE1"

ADR = E_{CTLIST} (Tag here "NEXTINCL", get here e.g. next interrupt after doing "DNPHASE1")

If ADR > 0:

CTLIST = CTLIST + 1

If ADR < 0:

CTLIST = - CTLIST (end of list reached)

DNECADR = $|$ADR$|$

If DNECADR = "TIME2": (i.e. computer clock)

Perform "C13STALL"

Set bit 7(Word Order Code) of channel 13 = 0

Proceed to "SETWO+2"

<u>SETWO+2</u>

TS = DNECADR - 30000_8

If TS ≤ 0: (i.e. bits 14-12 of DNECADR less than 6)

Proceed to "FETCH2WD"

TS = TS - 04000_8

If TS > 0: (i.e. bits 14-12 of DNECADR are 7)

TS_1 = Channel # (DNECADR - 34000_8 + 1) (Tag here "DODNCHAN")

TS_2 = Channel # (DNECADR - 34000_8) (34000_8 subtracts bits 14-12 = 7)

DNECADR = -1

Channel 34 = TS_2

Channel 35 = TS_1

Resume

SUBADR = $E_{DNECADR - 30000_8}$ (bits 14-12 of DNECADR are 6; tag here is "DODNPTR")

If SUBADR > 0:

SUBLIST = DNECADR

Proceed to "NEXTINSL"

SUBLIST = DNECADR SUBADR negative, meaning snapshot)

SUBADR = $|$SUBADR$|$ - 1

TMINDEX = 0

Proceed to "SNAPLOOP"

SNAPLOOP

EBANK = bits 11-9 of SUBADR

TS = 1401_8 + (bits 8-1 of SUBADR) (1401_8 instead of 1400_8 because of decrement in original setting of SUBADR)

$DNTMBUFF_{TMINDEX} = E_{TS_{dp}}$

TMINDEX = TMINDEX + 2

SUBLIST = SUBLIST + 1

SUBADR = $E_{SUBLIST} - 30000_8$

If SUBADR > 0:

SUBADR = SUBADR - 1

Proceed to "SNAPLOOP"

SUBLIST = |SUBADR| - 1

DNECADR = -1

TS = SUBLIST

SUBLIST = -1

EBANK = bits 11-9 of TS

TS = 1401_8 + (bits 8-1 of TS)

(Channel 34, Channel 35) = $E_{TS_{dp}}$

Resume

FETCH2WD

EBANK = bits 11-9 of DNECADR

TS = (bits 8-1 of DNECADR)

DNECADR = DNECADR + 74001_8 (subtracts 1 from bits 14-12 and adds 2, for double precision, to bits 11-1: $74001_8 = -04000_8 + 00002_8$)

TS = 1400_8 + TS

(Channel 34, Channel 35) = $E_{TS_{dp}}$

Resume

NEXTINSL

SUBADR = $E_{SUBLIST}$ - 30000_8

If SUBADR > 0:

SUBLIST = SUBLIST + 1

If SUBADR < 0:

SUBLIST = -1 (end of list reached)

DNECADR = |SUBADR|

Proceed to "SETWO+2"

DNDUMPI Entered by the setting of DNTMGOTO to "DNDUMPI" in "DNEDUMP" for a V74E

DUMPLOC = 0

Perform "SENDID"

DNTMGOTO = "DNDUMP1"

Channel 34 = DUMPLOC

Channel 35 = TIME1

Resume

SENDID

DNTMGOTO = Return address

Perform "C13STALL"

Set bit 7(Word Order Code) of channel 13 = 0

Channel 34 = 1777_8

Channel 35 = 77340_8

Resume

DNDUMP1

DNTMGOTO = "DNDUMP"

EBANK = bits 11-9 of DUMPLOC

TS = 1400_8 + (bits 8-1 of DUMPLOC)

(Channel 34, Channel 35) = $E_{TS_{dp}}$ (Read by mask using -0 to avoid affecting shift register cells, 0020_8 - 0023_8)

Resume

DNDUMP

DUMPLOC = DUMPLOC + 2 (modulo 2^{14})

If bits 8-1 of DUMPLOC $\neq$ 0:

Proceed to second line of "DNDUMP1"

If bit 13 of DUMPLOC = 1: (2 complete dumps)

Proceed to "DNPHASE1"

Proceed to second line of "DNDUMPI"

VAC5STOR — Entered from "BAILOUT", "GOPROG", and "POODOO" to save data in VAC area #5 for ground checking (after e.g. V74E)

$VAC5+3i_{dp}$ = $(LOC, BANKSET)_i$ (i = 0-6) Job register set starting addresses

$VAC5+2+3i$ = $PRIORITY_i$ (i = 0-6) Job priorities

$VAC5+19+2i_{dp}$ = (PHSNAMEi) (i = 1-6) 2CADR variable-type restarts starting addresses

VAC5+32+i = PHASEi (i = 1-6) Restart-group phase values

VAC5+39 = MPAC+3	Used in display interface routines for return address
$VAC5+40_{dp}$ = NEWLOC	Contains starting address for job being established
VAC5+22 = NEWJOB	Control of job selection
VAC5+26 = NEWPRIO	Priority of new job

Return

NOTE: See 3420.5-27 for details of the significance of the above quantities. They are intended to be an aid to determining "what happened" when other methods (such as flag words or program alarms) give insufficient detail. Use of these quantities would require access to the program listing, and a detailed understanding of the coding implementation. Such details (absolute machine addresses, and all restart points) can be obtained from the listing as necessary; they are not included in this document.

Quantities in Computations

See also list of major variables and list of routines

ADR: Single precision dummy cell used for temporary storage of the address information taken from the cell whose address is in CTLIST (i.e. the "control", or master, telemetry list). If it is read as negative, this means that the end of the master list (the final entry) has been reached. When the necessary number of telemetry transmissions have taken place based on this last entry, the list is started again (CTLIST is complemented if ADR is found negative, for control in "DNPHASE2").

CTLIST: Single precision cell initialized in "DNPHASE1" with the starting address for the "control", or master, telemetry list, and subsequently incremented in "DNPHASE2" as quantities are read from this list. When the final quantity is read, CTLIST is complemented (see ADR) to cause list to be restarted again.

DNECADR: Single precision erasable memory cell used to contain the address (and other) information associated with the transmission of a series of words based upon a single entry into the control or sublist table. Bits 8-1 give the S-register portion of the word in E-memory (the most significant half), while bits 11-9 give the EBANK. If bits 14-12 are in the range 0-5, they control the transmission of 1-6 respectively consecutive erasable memory pairs. While this transmission is going on, DNECADR will be positive, causing branching at the start of "DNPHASE2" to "FETCH2WD", where bits 14-12 are decremented by 1 and bits 11-1 incremented by 2 (for double precision operation). When final cell has been sent based on a given table entry, DNECADR becomes negative, allowing further checks in "DNPHASE2".
If bits 14-12 of DNECADR are 6, this means a "sublist" (i.e. a list of telemetry quantities that can be common to several master lists, hence serving as a quasi "sub-routine" list), with bits 11-1 giving its starting address. Finally, if these bits are 7, they indicate transmission of channel information.

DNLSTCOD: Single precision cell, scale factor B14, loaded by various mission programs (e.g. in V37 processing, transition to P11 or P62, or start of P27) with the desired serial number (in range 0-4) of the master downlist to be sent. It is used in "DNPHASE1" to index $K_{dntable}$ to select the proper starting address, and for list id.

DNTMBUFF: Set of 12 erasable memory cells which can be loaded in "SNAPLOOP" with values of quantities (such as vehicle state vector) requiring sampling at a single point in the computation cycle. A "snapshot" is indicated by bits 14-12 of DNECADR being 6 (a sublist) and the first word in that list being negative. Looping continues in "SNAPLOOP" until the next negative word is found: this word is not used for address information to be placed into DNTMBUFF, but instead is used to read the memory directly and send the indicated word. Consequently, 7 double precision cells, e.g. position, velocity, and time, can be subject to the "snapshot" process at a given telemetry interrupt.

DNTMGOTO: Single precision cell containing address to which transfer is to be made when a telemetry interrupt (#8) is received. Except for initialization, it would be expected to remain at "DNPHASE2" for normal (i.e. not erasable memory dump) downlists.

DUMPLOC: Single precision cell (assigned same erasable memory cell as TMINDEX) used to control the performance of the erasable memory dump program. Initialized to zero at the start of "DNDUMPI", and subsequently incremented by 2 in "DNDUMP" to permit selection of the next set of erasable memory cells. Bits 8-1 (000_8 - 377_8) select the cell within the erasable memory bank, since each bank has 256 cells. Bits 11-9 (carries propagate from bit 8, of course) select the erasable memory bank (0 - 7). Bits 13-12 serve as a counter of the number of complete erasable dumps which have been performed (when bit 13 becomes 1, indicating 2 dumps, dumps cease).

EBANK: See Data Input/Output.

$K_{dntable_i}$: Table of single precision starting addresses for master telemetry downlists, used in "DNPHASE1" to load the proper initial conditions for CTLIST based upon the present value of DNLSTCOD. Program notation for first table entry is "DNTABLE". Values are:

i	Starting Address	Identification of List Data
0	"CMCSTADL"	Coast and Align
1	"CMENTRDL"	Entry and Update
2	"CMRENDDL"	Rendezvous & Prethrust
3	"CMPOWEDL"	Powered
4	"CMPG22DL"	Program 22

SUBADR: Single precision dummy cell used for temporary storage of the address information taken from the cell whose address is in SUBLIST (i.e. a "sublist", see DNECADR). If it is read as negative, this means that the end of the sublist has been reached. When the necessary number of telemetry transmissions based on this last entry have taken place, the master list is used again (SUBLIST is set negative in "NEXTINSL", for control in "DNPHASE2"). Function is analogous to ADR's for a master list.

SUBLIST: Single precision cell initialized in "SETWO+2" to DNECADR for a non-snapshot list (for bits 14-12 of DNECADR = 6), giving then the starting address of the required sublist. While positive, "DNPHASE2" will transfer to "NEXTINSL" whenever DNECADR becomes negative: "NEXTINSL" increments SUBLIST until a negative readout (see SUBADR) is encountered, when SUBLIST is set to -1 to cause "DNPHASE2" to return to the master list. Function is analogous to CTLIST's for a master list. In "SNAPLOOP", it is used to index the readout of the snapshot sublist, and is left at -1 when "SNAPLOOP" is done to cause "DNPHASE2" to take next entry from master list (which should be a requirement to transmit DNTMBUFF cells).

TMINDEX: Single precision cell, scale factor B14, initialized to 0 in "SETWO+2" for use in indexing DNTMBUFF storage in "SNAPLOOP". It is assigned the same cell as DNECADR.

VAC5: First address in VAC area #5 (see 3420.5-27), the last to be assigned, and hence used in "VAC5STOR" to retain trouble-shooting information.

Information on the downlists appears on the following pages:

Telemetry Table Interpretation

To satisfy mission requirements, five different sets of downlinked memory cells can be specified. The mission program achieves the required specification by setting a quantity between 0 and 4 into DNLSTCOD (usually as part of the processing of a V37 program change). This quantity is used to index a table of fixed memory addresses in order to find the starting address of the particular list of downlinked memory cells required (powered flight, coast and align, etc.). In order to minimize the amount of fixed memory required for storage of this information, and maximize the flexibility of the information that is telemetered, a special storage format for the required addresses is used.

The table whose starting address is found by using DNLSTCOD is known as the "control" (or master) downlist. There is a separate such list for each different downlink set of information, and except for the first word in each 100-word set, the transmission of the information in the downlink set is under the control of information in this control list.

Within this control list, several different types of options can be employed:

a) A single (double precision, i.e. 2 consecutive erasable memory cells) downlink transmission can be specified. This is done by storing the ECADR (see 3420.5-27) of the first word in bits 11-1 of the fixed memory cell. The assembler operation is "1DNADR".

b) Two downlink transmissions (giving four cells in a row) can be specified. This is done by storing the ECADR for the first word in bits 11-1 of the fixed memory cell and putting a 1 in bit 12. The assembler operation in this case is "2DNADR".

c) Three downlink transmissions (giving six cells in a row) can be specified. Here again, the ECADR of the first word is in bits 11-1 of the fixed memory cell and a 1 is put in bit 13. The assembler operation in this case is "3DNADR".

d) Four, five, or six (giving 8, 10, or 12 cells in a row) can also be specified. The ECADR of the first word is in bits 11-1 of the fixed memory cell and bits 14-12 contain the (number - 1) of the transmissions desired: bit 14 is a 1 and bit 12 is a 1 for six transmissions, for example. The assembler operations are nDNADR.

e) A "sublist" can be specified. This permits a sequence of cells, such as state vector information, that may be common to more than one list to be specified only once (a sort of quasi "sub-routine" capability). In this case, bits 11-1 contain the address of the sublist (S-register portion, since in same bank) and bits 14-12 contain 6 (assembler operation is "DNPTR"). This particular assignment makes the 15-bit memory word of the form 3XXXX: rather than subtracting or masking out the "3" (as

indicated in this writeup), the coding takes advantage of the fact that this is the proper form for a "clear add" instruction (hence merely indexes on 00000_8).

f) A single downlink transmission of a pair of channels can be specified. In this case, bits 6-1 would contain the channel number and bits 14-12 would contain 7. The assembler operation for this is "DNCHAN", and advantage is taken of the "7" by indexing to form the required order, rather than subtracting or masking it out as indicated in this writeup.

g) The end of the control list (indicating that the list should be started again) is flagged by having the cell be negative (e.g. "-6DNADR" instead of "6DNADR").

If, per item e, a "sublist" in specified, then two options are available:

1. A "normal" sublist, in which case information can be stored in a manner exactly like the control list, except that option "e" should not be used (sublists cannot reference other sublists). The end of the sublist is flagged by a negative cell (as in option "g"), indicating in this case that information should again be taken from the control (master) list (at the line after the DNPTR).

2) A "snapshot" sublist, flagged by the fact that the first item in the sublist is negative (i.e. "-1DNADR"). The "snapshot" feature allows up to seven double precision words to be sampled at the same telemetry interrupt point, to achieve on the downlink a consistency of this information (e.g. position, velocity, and time of state vector). In this case, the remaining items in the sublist must be "1DNADR" form; the cell data specified by the first table entry through the next-to-last are stored in a special telemetry buffer (DNTMBUFF). The last entry in the sublist is negative, and in this case only is the first cell address transmitted. In all other cases, addresses in the lists are stored in the order in which they are transmitted. In order to cause transmission of the DNTMBUFF cells, the entry in the control list following the DNPTR cell for the snapshot should require transmission of DNTMBUFF cells (e.g. "6DNADR DNTMBUFF").

Except for specification of snapshot lists, which can occur only by DNPTR orders in the master (control) list, there is no maximum to the number of individual entries in either the control or sublists, except of course the convention that a complete telemetry cycle involves 100 double precision words. In addition, downlink processing format requires that word #51 (the computer clock) have a word order code bit of 0: a check for transmission of this word is made only for readouts from the master list (address 0024_8).

Information in Telemetered Words

There are five different downlists that may be transmitted during the flight (plus the special erasable memory dump initiated by a V74E). These five lists are implemented in the computer memory as the addresses of cells in erasable memory: the contents of the cells, in turn, can depend upon the phasing of the telemetry interrupts with respect to the other computations. In addition, cells are frequently time shared among different mission phases. The information below should be augmented by more detailed material on the telemetry data for items not covered.

Unless otherwise specified, the contents of the words below reflect both Channel 34 and Channel 35 (i.e. a double precision number). In those cases for which the information in the two channels is not closely related, "a" signifies the Channel 34 information and "b" the Channel 35 information.

Coast and Align List

This list, with starting address of "CMCSTADL", is selected for DNLSTCOD = 0. It is used in P00, P01, P02, P03, P06, P07, P51, P52, P53, and P54.

Word #	Quantity	Meaning
List Identification		
1a	77777_8	Identification of list (-0).
1b	77340_8	Special synchronization bits.
Snapshot Group #1		
		Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission. Cells for these words are those originally sampled.
2-4	$\underline{R}$	Position state vector (word 2 x component).
5-7	$\underline{V}$	Velocity state vector (word 5 x component).
8	T_{pptm}	State vector time.
Snapshot Group #2		
		Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.

Word #	Quantity	Meaning
9, 10a	$\underline{CDU}$	IMU CDU angles.
10b	CDUT	See Optics Computations.
11-13	$\underline{ADOT}$	See Digital Autopilot RCS Routines (same cell used for e.g. TVC DAP observed rates).

Erasable Group #1

Words 14-44 are sampled as the telemetry interrupt for them is received.

14,15a	$\underline{AK}$	See Digital Autopilot Interface Routines.
15b	RCSFLAGS	See Digital Autopilot Interface Routines.
16,17a	$\underline{THETADX}$	See Digital Autopilot RCS Routines (these are not N22 quantities).
17b	$DELCDUX_{sp}$	See Attitude Maneuvers.
18	T_{ig}	Ignition time (or predicted cutoff time).
19a	BESTI	See Inflight Alignment.
19b	BESTJ	See Inflight Alignment.
20-23a	MARKDOWN	Cells MARKDOWN+0 to MARKDOWN+6 (see Measurement Incorporation).
23b	RM	See Measurement Incorporation.
24-27a	MARK2DWN	Cells MARK2DWN+0 to MARK2DWN+6 (see Inflight Alignment).
27b	$DVPREV_{sp}$	See Rendezvous Computations.
28	HAPOX	See Display Computations.
29	HPERX	See Display Computations.
30a	PACTOFF	See Digital Autopilot TVC Routines.
30b	YACTOFF	See Digital Autopilot TVC Routines.
31-33	$\underline{V}_{gtig}$	See Burn Control.
34-36	$\underline{REFSMMAT}_0$	First row of [REFSMMAT].
37-39	$\underline{REFSMMAT}_3$	Second row of [REFSMMAT].

Word #	Quantity	Meaning
40-44	FLAGWRD0-FLAGWRD9	Program control flag words.

Display Table Group #1

		Words 45-50 are sampled as the telemetry interrupt for them is received.
45-50	DSPTAB+0-DSPTAB+11	"Display table" information (DSPTAB+0 is 45a). See Data Input/Output.

Computer Clock

		Word 51 is sampled when the telemetry interrupt for it is received.
51	T_{now}	Present value of computer clock (TIME2,TIME1).

Snapshot Group #3

		Words 52-58 are all sampled at the same telemetry interrupt time, with words 53-58 stored in DNTMBUFF for subsequent transmission.
52-54	$\underline{R}_{other}$	See Orbital Integration.
55-57	$\underline{V}_{other}$	See Orbital Integration.
58	T_{etlm}	See Orbital Integration.

Snapshot Group #4

		Words 59-63 are all sampled at the same telemetry interrupt time, with words 60-63 stored in DNTMBUFF for subsequent transmission.
59,60a	$CD\underline{U}$	IMU CDU angles.
60b	CDUT	See Optics Computations.
61-63	$ADO\underline{T}$	See Digital Autopilot RCS Routines (roll, pitch, yaw respectively).

Erasable Group #2

		Words 64-90 are sampled as the telemetry interrupt for them is received.
64	OPTION1,2	See Display Interface Routines.
65	T_{et}	See Orbital Integration.

Word #	Quantity	Meaning
66,67a	THETADX	See Digital Autopilot RCS Routines.
67b	$DELCDUX_{sp}$	See Attitude Maneuvers.
68	$RSBBQ_{dp}$	See General Program Control.
69a	Channel 76	Not meaningful.
69b	Channel 77	Hardware restart information.
70a	C31FLWRD	See Digital Autopilot RCS Routines.
70b,71	FAILREG	FAILREG+0 to FAILREG+2 (see General Program Control).
72a	CDUS	See Optics Computations.
72b,73	PIPA	See IMU Computations.
74	OGC	See Coordinate Transformations.
75	IGC	See Coordinate Transformations.
76	MGC	See Coordinate Transformations.
77a	FLGWRD10	Program control flag word.
77b	FLGWRD11	Program control flag word.
78	T_{evt}	Event (e.g. liftoff or engine on/off) time.
79	LAUNCHAZ	See Prelaunch Alignment.
80a	OPTMODES	See Optics Computations.
80b	HOLDFLAG	See Digital Autopilot Interface Routines.
81a	LEMMASS	See Digital Autopilot Interface Routines.
81b	CSMMASS	See Digital Autopilot Interface Routines.
82a	DAPDATR1	See Digital Autopilot Interface Routines.
82b	DAPDATR2	See Digital Autopilot Interface Routines.
83,84a	ERROR	See Digital Autopilot RCS Routines.
84b	THETADX	See Digital Autopilot RCS Routines.
85-87	WBODY	See Digital Autopilot RCS Routines (same cells used for commanded rates in TVC).

Word #	Quantity	Meaning
88a	REDOCTR	See General Program Control.
88b,89	THETAD	Desired CDU angles (e.g. N22).
90a	IMODES30	See IMU Computations.
90b	IMODES33	See IMU Computations.

Channel Quantities

Words 91-94 are sampled as the telemetry interrupt for them is received.

91a	Channel 11	Outputs.
91b	Channel 12	Outputs.
92a	Channel 13	Outputs.
92b	Channel 14	Outputs.
93a	Channel 30	Inputs.
93b	Channel 31	Inputs.
94a	Channel 32	Inputs.
94b	Channel 33	Inputs.

Display Table Group #2

Words 95-100 are sampled as the telemetry interrupt for them is received.

95-100	DSPTAB+0- DSPTAB+11	"Display table" information. See Data Input/Output.

Entry and Update List

This list, with starting address of "CMENTRDL", is selected for DNLSTCOD = 1. It is used in P27, P62, P63, P64, P65, P66, and P67.

Word #	Quantity	Meaning
List Identification		
1a	77776_8	Identification of list (-1).
1b	77340_8	Special synchronization bits.
Snapshot Group #1		
		Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission.
2-4	$\underline{R}$	Position state vector.
5-7	$\underline{V}$	Velocity state vector.
8	T_{pptm}	State vector time.
Snapshot Group #2		
		Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.
9, 10a	CDU$\underline{\ }$	IMU CDU angles.
10b	CDUT	See Optics Computations.
11-13	ADOT$\underline{\ }$	See Digital Autopilot RCS Routines (same cell used for e.g. TVC DAP observed rates). When Entry DAP is turned on, cells used for XPIPBUF$\underline{\ }$ and XOLDBUF$\underline{\ }$ (see General Program Control).
Erasable Group #1		
		Words 14-44 are sampled as the telemetry interrupt for them is received.
14,15a	AK$\underline{\ }$	See Digital Autopilot Interface Routines.
15b	RCSFLAGS	See Digital Autopilot Interface Routines.

Word #	Quantity	Meaning
16,17a	THETADX	See Digital Autopilot RCS Routines.
17b	$DELCDUX_{sp}$	See Attitude Maneuvers. In entry, word 17 contains Q7 (see Entry Computations) and word 16 contains (QAXERR, RAXERR) (see Digital Autopilot Entry Routines).
18a	CMDAPMOD	See Digital Autopilot Entry Routines.
18b	PREL	See Digital Autopilot Entry Routines.
19a	QREL	See Digital Autopilot Entry Routines.
19b	RREL	See Digital Autopilot Entry Routines.
20	LdD1	See Entry Computations.
21-30	UPBUFF	See Uplink Processing (UPBUFF+0 through UPBUFF+19). Same cells used during entry DAP for CMTMTIME, SWdNDX, and ENDBUF (see Digital Autopilot Entry Routines). Words 29b and 30a are also V1 (see Entry Computations), and 30b AO_{sp} (see Entry Computations).
31a	COMPNUMB	See Uplink Processing.
31b	UPOLDMOD	See Uplink Processing.
32a	UPVERB	See Uplink Processing.
32b	UPCOUNT	See Uplink Processing.
33a	PAXERR1	See Digital Autopilot Entry Routines.
33b	ROLLTM	See Digital Autopilot Entry Routines.
34	LATANG	See Entry Computations.
35	RDOT	See Entry Computations.
36	THETAH	See Entry Computations.
37	LATSPL	See Display Computations.
38	LNGSPL	See Display Computations.
39a	ALFAd180	See Entry Computations.
39b	BETAd180	See Entry Computations.
40-44	FLAGWRD0-FLAGWRD9	Program control flag words.

Word #	Quantity	Meaning
Display Table Group		
		Words 45-50 are sampled as the telemetry interrupt for them is received.
45-50	DSPTAB+0-DSPTAB+11	"Display table" information. See Data Input/Output.
Computer Clock		
		Word 51 is sampled when the telemetry interrupt for it is received.
51	T_{now}	Present value of computer clock (TIME2,TIME1).
Snapshot Group #3		
		Words 52-58 are all sampled at the same telemetry interrupt time, with words 53-58 stored in DNTMBUFF for subsequent transmission.
52	T_{pptml}	See IMU Computations.
53-55	$DEL\underline{V}$	Sampled accelerometer output (if least significant halves = 0, is uncompensated; otherwise is compensated data).
56	TTE	See Display Computations. Also used for LdDCALC (see Entry Computations).
57	VIO	See Display Computations. Also used for LEWD (see Entry Computations).
58	VPRED	See Display Computations. Also used for VL (see Entry Computations).
Snapshot Group #4		
		Words 59-63 are all sampled at the same telemetry interrupt time, with words 60-63 stored in DNTMBUFF for subsequent transmission.
59,60a	$CD\underline{U}$	IMU CDU angles.
60b	CDUT	See Optics Computations.
61-63	$ADO\underline{T}$	See Digital Autopilot RCS Routines. See also words 11-13 above in this list (which are same cells).

Word #	Quantity	Meaning
Erasable Group #2		
		Words 64-90 are sampled as the telemetry interrupt for them is received.
64	OPTION1,2	See Display Interface Routines.
65	T_{et}	See Orbital Integration.
66, 67a	ERROR	See Digital Autopilot RCS Routines.
67b,68	THETADX	See Digital Autopilot RCS Routines. Words 66-68 also contain (single precision): VDTd180, mVTd180E,unreflected LCXd360, QAXERR, RAXERR, and $Q7_{sp}$ (see Entry Computations for Q7 and Digital Autopilot Entry Routines for the others).
69a	CMDAPMOD	See Digital Autopilot Entry Routines.
69b	PREL	See Digital Autopilot Entry Routines.
70a	QREL	See Digital Autopilot Entry Routines.
70b	RREL	See Digital Autopilot Entry Routines.
71-80	UPBUFF	See Uplink Processing (UPBUFF+0 through UPBUFF+19). See also words 21-30 above (same cells).
81a	LEMMASS	See Digital Autopilot Interface Routines.
81b	CSMMASS	See Digital Autopilot Interface Routines.
82a	DAPDATR1	See Digital Autopilot Interface Routines.
82b	DAPDATR2	See Digital Autopilot Interface Routines.
83a	ROLLTM	See Digital Autopilot Entry Routines.
83b	$ROLLC_{sp}$	See Entry Computations.
84a	OPTMODES	See Optics Computations.
84b	HOLDFLAG	See Digital Autopilot Interface Routines.
85-87	WBODY	See Digital Autopilot RCS Routines. Same cells used for commanded rates in TVC. They are also loaded with ASPSpTMp (see Entry Computations).
88a	REDOCTR	See General Program Control.

Word #	Quantity	Meaning
88b,89	THETA$\underline{D}$	Desired CDU angles (e.g. N22). Same cells for RDOTREF and $VREF_{sp}$ (see Entry Computations).
90a	IMODES30	See IMU Computations.
90b	IMODES33	See IMU Computations.

Channel Quantities

Words 91-94 are sampled as the telemetry interrupt for them is received.

91a	Channel 11	Outputs.
91b	Channel 12	Outputs.
92a	Channel 13	Outputs.
92b	Channel 14	Outputs.
93a	Channel 30	Inputs.
93b	Channel 31	Inputs.
94a	Channel 32	Inputs.
94b	Channel 33	Inputs.

Erasable Group #3

Words 95-100 are sampled as the telemetry interrupt for them is received.

95	$RSBBQ_{dp}$	See General Program Control.
96a	Channel 76	Not meaningful.
96b	Channel 77	Hardware restart information.
97a	C31FLWRD	See Digital Autopilot RCS Routines.
97b,98	FAILREG	FAILREG+0 to FAILREG+2 (see General Program Control).
99a	FLGWRD10	Program control flag word.
99b	FLGWRD11	Program control flag word.
100a	GAMMAEI	See Display Computations. Same cell used for PREDANG (see Entry Computations), and GAMMAL.
100b	JJ	Loaded with $RTGO_{sp}$ (see Display Computations); JJ itself is in Entry Computations.

Rendezvous and Prethrust List

This list, with starting address of "CMRENDDL", is selected for DNLSTCOD = 2. It is used in P20, P21, P23, P29, P30, P31, P32, P33, P34, P35, P36, P37, P72, P73, P74, P75, P76, P77, and P79 (and "P81" - "P86").

Word #	Quantity	Meaning
List Identification		
1a	77775_8	Identification of list (-2).
1b	77340_8	Special synchronization bits.
Snapshot Group #1		
		Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission.
2-4	$\underline{R}$	Position state vector.
5-7	$\underline{V}$	Velocity state vector.
8	T_{pptm}	State vector time.
Snapshot Group #2		
		Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.
9,10a	$\mathrm{CD}\underline{\mathrm{U}}$	IMU CDU angles.
10b	CDUT	See Optics Computations.
11-13	$\mathrm{ADO}\underline{\mathrm{T}}$	See Digital Autopilot RCS Routines (same cell used for e.g. TVC DAP observed rates).
Erasable Group #1		
		Words 14-44 are sampled as the telemetry interrupt for them is received.
14,15a	$\mathrm{A}\underline{\mathrm{K}}$	See Digital Autopilot Interface Routines.
15b	RCSFLAGS	See Digital Autopilot Interface Routines.
16,17a	$\mathrm{THETAD}\underline{\mathrm{X}}$	See Digital Autopilot RCS Routines.
17b	$\mathrm{DELCDUX}_{sp}$	See Attitude Maneuvers.

Word #	Quantity	Meaning
18	T_{ig}	Ignition time (or predicted cutoff time).
19	DELLT4	See Rendezvous Computations.
20-22	$\underline{R}_{targ}$	See Rendezvous Computations.
23	VHFTIME	See Measurement Incorporation.
24-27a	MARKDOWN	Cells MARKDOWN+0 to MARKDOWN+6 (see Measurement Incorporation).
27b	RM	See Measurement Incorporation.
28a	VHFCNT	See Measurement Incorporation.
28b	TRKMKCNT	See Measurement Incorporation.
29	T_{tpi}	See Rendezvous Computations.
30a	ECSTEER	See Burn Control.
30b	$DVTOTAL_{sp}$	See General Program Control (cell also used for attitude maneuver matrix elements).
31	DELVTPF	See Burn Control.
32	T_{cdh}	See Rendezvous Computations.
33	T_{csi}	See Rendezvous Computations.
34	T_{pass4}	See Burn Control.
35-37	DELVLV$\underline{C}$	See Burn Control.
38	RANGE	See Display Computations. Same cell used for RHOSB (Display Computations) and WWPOS (see Measurement Incorporation).
39	RRATE	See Display Computations. Same cell used for GAMMASB (Display Computations) and WWVEL (see Measurement Incorporation).
40-44	FLAGWRD0-FLAGWRD9	Program control flag words.

Display Table Group

Words 45-50 are sampled as the telemetry interrupt for them is received.

Word #	Quantity	Meaning
45-50	DSPTAB+0-DSPTAB+11	"Display table" information. See Data Input/Output.
Computer Clock		
		Word 51 is sampled when the telemetry interrupt for it is received.
51	T_{now}	Present value of computer clock (TIME2,TIME1).
Snapshot Group #3		
		Words 52-58 are all sampled at the same telemetry interrupt time, with words 53-58 stored in DNTMBUFF for subsequent transmission.
52-54	$\underline{R}_{other}$	See Orbital Integration.
55-57	$\underline{V}_{other}$	See Orbital Integration.
58	T_{etlm}	See Orbital Integration.
Snapshot Group #4		
		Words 59-63 are all sampled at the same telemetry interrupt time, with words 60-63 stored in DNTMBUFF for subsequent transmission.
59,60a	$CD\underline{U}$	IMU CDU angles.
60b	CDUT	See Optics Computations.
61-63	$ADO\underline{T}$	See Digital Autopilot RCS Routines.
Erasable Group #2		
		Words 64-90 are sampled as the telemetry interrupt for them is received.
64	OPTION1,2	See Display Interface Routines.
65	T_{et}	See Orbital Integration.
66,67a	$THETAD\underline{X}$	See Digital Autopilot RCS Routines.
67b	$DELCDUX_{sp}$	See Attitude Maneuvers.
68	$RSBBQ_{dp}$	See General Program Control.
69a	Channel 76	Not meaningful.
69b	Channel 77	Hardware restart information.
70a	C31FLWRD	See Digital Autopilot RCS Routines.

Word #	Quantity	Meaning
70b,71	FAILREG	FAILREG+0 to FAILREG+2 (see General Program Control).
72a	CDUS	See Optics Computations.
72b,73	PIPA	See IMU Computations.
74	DIFFALT	See Rendezvous Computations.
75	CENTANG	See Burn Control.
76	Spare	76a = 0; 76b = accumulator when interrupt.
77-79	DELVEET3	See Rendezvous Computations.
80a	OPTMODES	See Optics Computations.
80b	HOLDFLAG	See Digital Autopilot Interface Routines.
81a	LEMMASS	See Digital Autopilot Interface Routines.
81b	CSMMASS	See Digital Autopilot Interface Routines.
82a	DAPDATR1	See Digital Autopilot Interface Routines.
82b	DAPDATR2	See Digital Autopilot Interface Routines.
83,84a	ERROR	See Digital Autopilot RCS Routines.
84b	THETADX	See Digital Autopilot RCS Routines.
85-87	WBODY	See Digital Autopilot RCS Routines (same cells used for commanded rates in TVC).
88a	REDOCTR	See General Program Control.
88b,89	THETAD	Desired CDU angles (e.g. N22).
90a	IMODES30	See IMU Computations.
90b	IMODES33	See IMU Computations.

Channel Quantities

Words 91-94 are sampled as the telemetry interrupt for them is received.

91a	Channel 11	Outputs.
91b	Channel 12	Outputs.

Word #	Quantity	Meaning
92a	Channel 13	Outputs.
92b	Channel 14	Outputs.
93a	Channel 30	Inputs.
93b	Channel 31	Inputs.
94a	Channel 32	Inputs.
94b	Channel 33	Inputs.
Erasable Group #3		
		Words 95-100 are sampled as the telemetry interrupt for them is received.
95	RTHETA	See Display Computations. Same cell is used for WWOPT (see Measurement Incorporation).
96	LATSPL	See Display Computations(or Return to Earth).
97	LNGSPL	See Display Computations(or Return to Earth).
98	VPRED	See Display Computations (or Return to Earth).
99	GAMMAEI	See Display Computations (or Return to Earth).
100a	FLGWRD10	Program control flag word.
100b	FLGWRD11	Program control flag word.

Powered List

This list, with starting address of "CMPOWEDL", is selected for DNLSTCOD = 3. It is used in P11, P15, P40, P41, P47, and P61.

Word #	Quantity	Meaning
List Identification		
1a	77774_8	Identification of list (-3).
1b	77340_8	Special synchronization bits.
Snapshot Group #1		
		Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission.
2-4	$\underline{R}$	Position state vector.
5-7	$\underline{V}$	Velocity state vector.
8	T_{pptm}	State vector time.
Snapshot Group #2		
		Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.
9,10a	CDU$\underline{U}$	IMU CDU angles.
10b	CDUT	See Optics Computations.
11-13	ADO$\underline{T}$	See Digital Autopilot RCS Routines. Same cells are used for OMEGA$\underline{B}$ (see Digital Autopilot TVC Routines).
Erasable Group #1		
		Words 14-44 are sampled as the telemetry interrupt for them is received.
14,15a	A$\underline{K}$	See Digital Autopilot Interface Routines.
15b	RCSFLAGS	See Digital Autopilot Interface Routines.
16,17a	THETAD$\underline{X}$	See Digital Autopilot RCS Routines.
17b	$DELCDUX_{sp}$	See Attitude Maneuvers.

Word #	Quantity	Meaning
18	T_{ig}	Ignition time (or predicted cutoff time).
19	DELLT4	See Rendezvous Computations.
20-22	$\underline{R}_{targ}$	See Rendezvous Computations.
23	T_{go}	See Steering Computations. Should not be confused with T_{togo} (Burn Computations) of N40 etc.
24	T_{pptml}	See IMU Computations.
25-27	DEL$\underline{V}$	Sampled accelerometer output (if least significant half zero, is uncompensated; otherwise is compensated data).
28a	PACTOFF	See Digital Autopilot TVC Routines.
28b	YACTOFF	See Digital Autopilot TVC Routines.
29a	PCMD	See Digital Autopilot TVC Routines.
29b	YCMD	See Digital Autopilot TVC Routines.
30	CSTEER	See Steering Computations (30b = 0).
31-33	DELVEET$\underline{1}$	See Rendezvous Computations.
34-36	REFSMMA$\underline{T}_0$	First row of [REFSMMAT].
37-39	REFSMMA$\underline{T}_3$	Second row of [REFSMMAT].
40-44	FLAGWRD0-FLAGWRD9	Program control flag words.

Display Table Group

Words 45-50 are sampled as the telemetry interrupt for them is received.

Word #	Quantity	Meaning
45-50	DSPTAB+0-DSPTAB+11	"Display table" information. See Data Input/Output.

Word #	Quantity	Meaning
Computer Clock		
		Word 51 is sampled when the telemetry interrupt for it is received.
51	T_{now}	Present value of computer clock (TIME2,TIME1).
Snapshot Group #3		
		Words 52-58 are all sampled at the same telemetry interrupt time, with words 53-58 stored in DNTMBUFF for subsequent transmission.
52-54	$\underline{R}_{other}$	See Orbital Integration.
55-57	$\underline{V}_{other}$	See Orbital Integration.
58	T_{etlm}	See Orbital Integration.
Snapshot Group #4		
		Words 59-63 are all sampled at the same telemetry interrupt time, with words 60-63 stored in DNTMBUFF for subsequent transmission.
59,60a	CDU<u>U</u>	IMU CDU angles.
60b	CDUT	See Optics Computations.
61-63	ADO<u>T</u>	See Digital Autopilot RCS Routines. Same cells are used for OMEGA<u>B</u> (see Digital Autopilot TVC Routines).
Erasable Group #2		
		Words 64-90 are sampled as the telemetry interrupt for them is received.
64,65a	A<u>K</u>	See Digital Autopilot Interface Routines.
65b	RCSFLAGS	See Digital Autopilot Interface Routines.
66,67a	THETAD<u>X</u>	See Digital Autopilot RCS Routines.
67b	$DELCDUX_{sp}$	See Attitude Maneuvers.
68	$RSBBQ_{dp}$	See General Program Control.
69a	Channel 76	Not meaningful.
69b	Channel 77	Hardware restart information.
70a	C31FLWRD	See Digital Autopilot RCS Routines.

Word #	Quantity	Meaning
70b,71	FAILREG	FAILREG+0 to FAILREG+2 (see General Program Control).
72a	CDUS	See Optics Computations.
72b,73	PIPA	See IMU Computations.
74	ELEV	See Rendezvous Computations.
75	CENTANG	See Burn Control.
76	Spare	76a = 0; 76b = accumulator when interrupt.
77a	FLGWRD10	Program control flag word.
77b	FLGWRD11	Program control flag word.
78	T_{evt}	Event (e.g. liftoff or engine on/off) time.
79a	PCMD	See Digital Autopilot TVC Routines.
79b	YCMD	See Digital Autopilot TVC Routines.
80a	OPTMODES	See Optics Computations.
80b	HOLDFLAG	See Digital Autopilot Interface Routines.
81a	LEMMASS	See Digital Autopilot Interface Routines.
81b	CSMMASS	See Digital Autopilot Interface Routines.
82a	DAPDATR1	See Digital Autopilot Interface Routines.
82b	DAPDATR2	See Digital Autopilot Interface Routines.
83,84a	ERROR	See Digital Autopilot RCS Routines.
84b	THETADX	See Digital Autopilot RCS Routines.
85-87	WBODY	See Digital Autopilot RCS Routines. Same cells used for OMEGAC (see Digital Autopilot TVC Routines).
88a	REDOCTR	See General Program Control.
88b,89	THETAD	Desired CDU angles (e.g. N22).
90a	IMODES30	See IMU Computations.
90b	IMODES33	See IMU Computations.

Word #	Quantity	Meaning
Channel Quantities		
		Words 91-94 are sampled as the telemetry interrupt for them is received.
91a	Channel 11	Outputs.
91b	Channel 12	Outputs.
92a	Channel 13	Outputs.
92b	Channel 14	Outputs.
93a	Channel 30	Inputs.
93b	Channel 31	Inputs.
94a	Channel 32	Inputs.
94b	Channel 33	Inputs.
Erasable Group #3		
		Words 95-100 are sampled as the telemetry interrupt for them is received.
95-97	$\underline{V}_{gtig}$	See Burn Control. Word 96 is also VMAGI and word 97 VGTLI (see Boost Computations).
98-100	DELVEET2	See Rendezvous Computations.

Program 22 List

This list, with starting address of "CMPG22DL", is selected for DNLSTCOD = 4. It is used in P22 and P24.

Word #	Quantity	Meaning
List Identification		
1a	77773_8	Identification of list (-4).
1b	77340_8	Special synchronization bits.
Snapshot Group #1		
		Words 2-8 are all sampled at the same telemetry interrupt time, with words 3-8 stored in DNTMBUFF for subsequent transmission.
2-4	$\underline{R}$	Position state vector.
5-7	$\underline{V}$	Velocity state vector.
8	T_{pptm}	State vector time.
Snapshot Group #2		
		Words 9-13 are all sampled at the same telemetry interrupt time, with words 10-13 stored in DNTMBUFF for subsequent transmission.
9,10a	CDU$\underline{\text{U}}$	IMU CDU angles.
10b	CDUT	See Optics Computations.
11-13	ADO$\underline{\text{T}}$	See Digital Autopilot RCS Routines.
Erasable Group #1		
		Words 14-17 are sampled as the telemetry interrupt for them is received.
14,15a	A$\underline{\text{K}}$	See Digital Autopilot Interface Routines.
15b	RCSFLAGS	See Digital Autopilot Interface Routines.
16,17a	THETAD$\underline{\text{X}}$	See Digital Autopilot RCS Routines.
17b	DELCDUX_{sp}	See Attitude Maneuvers.

Word #	Quantity	Meaning
Snapshot Group #3		
		Words 18-24 are all sampled at the same telemetry interrupt time, with words 19-24 stored in DNTMBUFF for subsequent transmission.
18-24	SVMRKDAT+0 - SVMRKDAT+13	See Orbital and Rendezvous Navigation. Represents data from two complete sets of marks.
Snapshot Group #4		
		Words 25-31 are all sampled at the same telemetry interrupt time, with words 26-31 stored in DNTMBUFF for subsequent transmission.
25-31	SVMRKDAT+14 - SVMRKDAT+27	See Orbital and Rendezvous Navigation. Represents data from two complete sets of marks.
Snapshot Group #5		
		Words 32-35 are all sampled at the same telemetry interrupt time, with words 33-35 stored in DNTMBUFF for subsequent transmission.
32-35	SVMRKDAT+28 - SVMRKDAT+35	See Orbital and Rendezvous Navigation. Represents data from one complete set of marks. The final data point is in word 35a, with 35b not meaningful.
Erasable Group #2		
		Words 36-44 are sampled as the telemetry interrupt for them is received.
36a	LANDMARK	See Orbital and Rendezvous Navigation.
36b	HORIZON	See Measurement Incorporation.
37	Spare	37a = 0; 37b = accumulator when interrupt.
38	Spare	38a = 0; 38b = accumulator when interrupt.
39	Spare	39a = 0; 39b = accumulator when interrupt.
40-44	FLAGWRD0- FLAGWRD9	Program control flag words.
Display Table Group		
		Words 45-50 are sampled as the telemetry interrupt for them is received.
45-50	DSPTAB+0- DSPTAB+11	"Display table" information. See Data Input/Output.

Word #	Quantity	Meaning
Computer Clock		
		Word 51 is sampled when the telemetry interrupt for it is received.
51	T_{now}	Present value of computer clock (TIME2,TIME1).
Snapshot Group #6		
		Words 52-54 are all sampled at the same telemetry interrupt time, with words 53-54 stored in DNTMBUFF for subsequent transmission.
52	LAT	See Coordinate Transformations.
53	LONG	See Coordinate Transformations.
54	ALT	See Coordinate Transformations.
55	Spare	55a = 0; 55b = accumulator when interrupt.
56	Spare	56a = 0; 56b = accumulator when interrupt.
57	Spare	57a = 0; 57b = accumulator when interrupt.
58	Spare	58a = 0; 58b = accumulator when interrupt.
Snapshot Group #7		
		Words 59-63 are all sampled at the same telemetry interrupt time, with words 60-63 stored in DNTMBUFF for subsequent transmission.
59,60a	$CD\underline{U}$	IMU CDU angles.
60b	CDUT	See Optics Computations.
61-63	$ADO\underline{T}$	See Digital Autopilot RCS Routines.
Erasable Group #3		
		Words 64-90 are sampled as the telemetry interrupt for them is received.
64	OPTION1,2	See Display Interface Routines.
65	T_{et}	See Orbital Integration.
66,67a	$THETAD\underline{X}$	See Digital Autopilot RCS Routines.
67b	$DELCDUX_{sp}$	See Attitude Maneuvers.
68	$RSBBQ_{dp}$	See General Program Control.
69a	Channel 76	Not meaningful.

Word #	Quantity	Meaning
69b	Channel 77	Hardware restart information.
70a	C31FLWRD	See Digital Autopilot RCS Routines.
70b,71	FAILREG	FAILREG+0 to FAILREG+2 (see General Program Control).
72a	CDUS	See Optics Computations.
72b,73	PIPA	See IMU Computations.
74a	NUM8NN	See Orbital and Rendezvous Navigation.
74b	S22LOC	See Orbital and Rendezvous Navigation.
75a	FLGWRD10	Program control flag word.
75b	FLGWRD11	Program control flag word.
76-78	RLS	See Coordinate Transformations.
79	Spare	79a = 0; 79b = accumulator when interrupt.
80a	OPTMODES	See Optics Computations.
80b	HOLDFLAG	See Digital Autopilot Interface Routines.
81a	LEMMASS	See Digital Autopilot Interface Routines.
81b	CSMMASS	See Digital Autopilot Interface Routines.
82a	DAPDATR1	See Digital Autopilot Interface Routines.
82b	DAPDATR2	See Digital Autopilot Interface Routines.
83,84a	ERROR	See Digital Autopilot RCS Routines.
84b	THETADX	See Digital Autopilot RCS Routines.
85-87	WBODY	See Digital Autopilot RCS Routines.
88a	REDOCTR	See General Program Control.
88b,89	THETAD	Desired CDU angles (e.g. N22).
90a	IMODES30	See IMU Computations.
90b	IMODES33	See IMU Computations.

Channel Quantities

		Words 91-94 are sampled as the telemetry interrupt for them is received.
91a	Channel 11	Outputs.

Word #	Quantity	Meaning
91b	Channel 12	Outputs.
92a	Channel 13	Outputs.
92b	Channel 14	Outputs.
93a	Channel 30	Inputs.
93b	Channel 31	Inputs.
94a	Channel 32	Inputs.
94b	Channel 33	Inputs.
95-100	Spare	For all 6 words, the "a" part is 0 and the "b" part is accumulator when interrupt.

Special Erasable Memory Dump List

Input of a V74E causes DNTMGOTO to be switched so as to start at the next telemetry interrupt the transmission of a "dump" of the erasable memory (all cells are sent sequentially for two times, i.e. two complete passes through the erasable memory). The erasable memory hardware is divided into eight "banks" of 256 cells each, and a similar division is made for downlinking of information: the first two words are used for control data, and the next 128 contain the 256 words in the particular bank set identified by the first two words. The format of the information is:

Word #	Quantity	Meaning
List Identification		
1a	01777_8	Identification of list.
1b	77340_8	Special synchronization bits.
2a	DUMPLOC	See Telemetry (page TELE-7).
2b	TIME1	Least significant half of computer clock.
Erasable Memory Bank		
3-130	Cells in bank (addresses sent in consecutive increasing order).	

Testing Routines

SELFCHK   Address set as initial condition for SELFRET in "STARTSB2"

Perform "SMODECHK" (will not return unless self-check is desired)

Proceed to "ERASCHK"

SMODECHK

SKEEP1 = Return address

Perform "CHECKNJ"   (returns immediately if no new job waiting, and otherwise returns after doing job(s))

If SMODE = +0:

Proceed to second line of "SMODECHK"

If $|\text{SMODE}| \leq 8$:

SCOUNT = SCOUNT + 1

If SMODE = -0, proceed to address specified by SKEEP1

If $|\text{SMODE}|$ = 1, 2, 3, 6, 7, or 8:   (10_8 = decimal 8)

Proceed to address specified by SKEEP1

If $|\text{SMODE}|$ = 4, proceed to "ERASCHK"

If $|\text{SMODE}|$ = 5, proceed to "ROPECHK"

SMODE = 0   (magnitude exceeded 8)

Proceed to "SELFCHK"

PRERRORS

If ERESTORE = 0, proceed to "ERRORS"

$E_{\text{SKEEP7}} = \text{SKEEP5}_{\text{dp}}$

ERESTORE = 0

Proceed to "ERRORS"

ERRORS

Inhibit interrupts (released upon return from alarm routine)

SFAIL = Return address (to routine calling "PRERRORS" or "ERRORS")

ALMCADR = SFAIL

ERCOUNT = ERCOUNT + 1

Perform "ALARM2" (pattern 1102_8)

If SMODE = -0:

Proceed to address specified by SFAIL

If SMODE > 0:

SMODE = +0

Proceed to "SELFCHK"

<u>ERASCHK</u>

SKEEP2 = 1 (flag to check cells 0061_8 - 1373_8)

EBANK = 0

SKEEP7 = 1461_8 (first cell in bank 0 to be checked, since cells 0 - 60_8 are "special" erasable cells)

SKEEP3 = 1777_8 (last cell)

Proceed to "ERASLOOP"

<u>ERASLOOP</u>

Inhibit interrupts

SKEEP4 = EBANK (non-zero EBANK loads bits 11-9)

$SKEEP5_{dp} = E_{SKEEP7_{dp}}$ (address also determined by EBANK)

ERESTORE = SKEEP7

E_{SKEEP7} = SKEEP7 (loads with own S-register address)

$E_{SKEEP7+1}$ = SKEEP7 + 1

If $E_{SKEEP7} - E_{SKEEP7+1} \neq -1$, perform "PRERRORS"

If ERESTORE $\neq$ 0:

$E_{SKEEP7_{dp}} = - E_{SKEEP7_{dp}}$

If $E_{SKEEP7+1} - E_{SKEEP7} \neq -1$, perform "PRERRORS"

If ERESTORE $\neq$ 0:

$E_{SKEEP7_{dp}} = SKEEP5_{dp}$

ERESTORE = 0

Release interrupts

Perform "CHECKNJ"

EBANK = bits 11-9 of SKEEP4

SKEEP7 = SKEEP7 + 1

If SKEEP3 - SKEEP7 $\neq$ 0:

    Proceed to "ERASLOOP"

If SKEEP2 $>$ 0:

    SKEEP2 = SKEEP2 - 1 (sets 0)

    SKEEP7 = 0061_8 (unswitched erasable form of bank 0)

    SKEEP3 = 1373_8 (SKEEP4 - SKEEP7 not checked, cells 1374 - 7)

    Proceed to "ERASLOOP"

SKEEP2 = 1

EBANK = EBANK + 1, modulo 8 (7 + 1 = 0)

If EBANK = 2:

    SKEEP7 = 1400_8

    SKEEP3 = 1773_8 (cells 1374-7 not checked)

    Proceed to "ERASLOOP"

If EBANK $\neq$ 0:

    SKEEP7 = 1400_8

    SKEEP3 = 1777_8

    Proceed to "ERASLOOP"

EBANK = 3

Read out cells from 0060_8 to 0010_8 to check on their parity (addresses 0007_8 - 0000_8 have no parity bits), by a CS (Clear Subtract) order

Check cycle and shifting registers; if difficulty, perform "PRERRORS"

SCOUNT+1 = SCOUNT+1 + 1

Perform "SMODECHK"

Proceed to "ROPECHK" (if return from "SMODECHK")

ROPECHK

SKEEP6 = -0 (indicates "ROPECHK" option)

SKEEP4 = 0 (bank number)

SKEEP7 = 1 (counter for reading fixed-fixed banks)

SKEEP1 = 0 (sum)

SKEEP3 = 0 (address read)

SKEEP5 = 1 (counts two TC self words for end of bank data)

Proceed to "COMADRS"

SHOWSUM+2 Entered from "GOSHOSUM" for V91E

SKEEP6 = 1 (indicates "SHOWSUM" option)

SMODE = +0

SELFRET = "SELFCHK"

Proceed to second line of "ROPECHK"

COMADRS

$SKEEP2 = E_{SKEEP3,SKEEP4}$ (address determined by 2000_8 + SKEEP3 for S-register; bits 15-11 of SKEEP4 for FBANK; bits 7-5 of SKEEP4 for FEXT)

SKEEP1 = SKEEP1 + SKEEP2

If $|SKEEP1| \geq 16384$:

SKEEP1 = SKEEP1 - 16383 sgn SKEEP1

$TS = (2000_8 + SKEEP3) - SKEEP2$ (zero if cell contains TC self order, since TC is op code "0")

Proceed to "ADRSCHK"

ADRSCHK

If bits 10-1 of SKEEP3 = 1777_8, proceed to "SOPTION" (just read last bank cell)

If SKEEP5 < 0, proceed to "SOPTION" (just read cell following two TC self orders)

If TS $\neq$ 0, SKEEP5 = 1

If TS = 0, SKEEP5 = SKEEP5 - 1 (goes +1, +0, -1)

If SKEEP6 = -0:

Perform "CHECKNJ"

If SKEEP6 > 0:

Check NEWJOB cell for job of higher priority than present job (which has priority 30_8 from "KEYCOM"), and do that job if it exists, proceeding when present job again of highest priority.

SKEEP3 = SKEEP3 + 1

If SKEEP7 $\ngtr$ +0, proceed to "COMADRS"

Proceed to "FXADRS"

FXADRS

SKEEP2 = E_{SKEEP3} (S-register contents determined by SKEEP3 only for fixed-fixed memory cell)

SKEEP1 = SKEEP1 + SKEEP2

If |SKEEP1| $\ngtr$ 16384:

SKEEP1 = SKEEP1 - 16383 sgn SKEEP1

TS = SKEEP3 - SKEEP2

Proceed to "ADRSCHK"

SOPTION

TS = bits 15-11 of SKEEP4, cycled left 5 places (puts FBANK information in bits 5-1)

If bits 8-1 of SKEEP4 $\neq$ 0: (reading super-bank cells, i.e. $\ngtr 30_8$)

TS = bits 3-1 of TS + (bits 8-2 of SKEEP4 shifted right 1 place)

If SKEEP6 > 0:

SKEEP3 = SKEEP2

SKEEP2 = TS

MPAC+2 = "SKEEP1"

(If SKEEP6 $>$ 0):

TS = 0501_{vn}

Proceed to "GOXDSPF": if terminate, proceed
if proceed, proceed to "NXTBNK"
otherwise, proceed to second previous line (reload MPAC+2)

SKEEP1 = "SELFCHK"

Proceed to "ENDEXT"

SKEEP1 = |SKEEP1|

If SKEEP1 - TS - 1 $\neq$ -1, perform "PRERRORS"

Proceed to "NXTBNK"

<u>NXTBNK</u>

If SKEEP4 = K_{stbnk}:

If SKEEP6 $>$ 0, proceed to second line of "ROPECHK"

Proceed to "SELFCHK"

Increment bits 14-11 of SKEEP4 by 1 (FBANK scaling)

If SKEEP4 overflows (i.e. previous value of these bits 17_8):

SKEEP4 = 20_8 (in bits 15-11)

If SKEEP4 bits 15-11 = 0 (i.e. previous value 37_8):

SKEEP4 = SKEEP4 + 60020_8 (sets FBANK to 30_8 in bits 15-11, and increments FEXT in bits 7-5)

If SKEEP4 = 60000_8: (bits 15-11 = 30_8)

SKEEP4 = 60060_8 (sets FEXT bits, 7-5, to 3)

If SKEEP7 $>$ 0:

SKEEP7 = SKEEP7 - 1, limited $\geq$ +0

Proceed to fourth line of "ROPECHK"

If SKEEP7 = +0:

TS = 1

Proceed to "FXFX"

If SKEEP7 = -1:

TS = +0

Proceed to "FXFX"

If SKEEP7 = -0:

SKEEP7 = 64 (larger than number of remaining banks)

Proceed to fourth line of "ROPECHK"

<u>FXFX</u>

SKEEP7 = - TS

If TS $\neq$ 0:

SKEEP3 = 04000_8 (first cell in "bank 2")

If TS = 0:

SKEEP3 = 06000_8 (first cell in "bank 3")

SKEEP1 = 0

SKEEP5 = 1

Proceed to "FXADRS"

IMU Performance Testing

The computations associated with the IMU performance testing (P07) have been partially removed from fixed memory. For continuity purposes, the following information on the computations formerly done at the start of P07 (based on the H2 flight program) is provided.

1. Program display set to 07.
2. $DRIFTT_{sp}$ set 0.
3. GEOCOMP1 set 0 (logic checking for this cell = 0 <u>not</u> shown).
4. LENGTHOT set to 898 seconds.
5. 1SECXT1 and 1dPIPADT set to one second interval.
6. WANGI set to - cos C_{atd}; WANGO set to sin C_{atd}.
7. IMU coarse aligned to 0^o.
8. Computations progressed to "GEOIMUTT".

GEOIMUTT

Perform "IMUZERO"

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

NDXCTR = 0

WANGT = 0

$\underline{X}_{dc}$ = (1, 0, 0)

$\underline{Y}_{dc}$ = (0, sin C_{azmth}, cos C_{azmth})

$\underline{Z}_{dc}$ = (0, - cos C_{azmth}, sin C_{azmth})

Perform "CALCGA" (here if MODREG $\neq$ 3, since should be 7)

Perform "IMUCOARS"

If bit 14(GLOKFAIL) of FLAGWRD3 = 1:

NDXCTR = NDXCTR + 1

Set bit 14(GLOKFAIL) of FLAGWRD3 = 0

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

If NDXCTR > 0:

Proceed to "PIPACHK"

Perform "IMUFINE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

Call "$GOESTIMS_d$" in $PERFDLAY_{dp}$ centi-seconds

Put present job to sleep (starting address id = "$ESTIMS_d$")

$GOESTIMS_d$

Awaken job with starting address id = "$ESTIMS_d$"

End of task (since WANGT = 0, "ONCEMORE" will go to "TORQUE")

ESTIMS$_d$

Inhibit interrupts

GTSWTLT1 = TIME1

PIP$\underline{A}$ = 0

Release interrupts

Zero erasable memory cells 5,1453 - 5,1570: includes least significant half of DRIFTT, KGAINAZ, KGAINVRD, KGAINNSD, ANGX, ANGY, ANGZ, INTY, INTZ, DRIFTO, DRIFTI, VLAUN$_y$, VLAUN$_z$, ACCWD$_y$, ACCWD$_z$, POSNV$_y$, POSNV$_z$, and ALTIM.

GCOMPSW = 0

ALX1S = 144

CMPX1 = -1

KGAINPIP = K_{soupy0}

KGAINERC = K_{soupy2}

GCOM$\underline{P}$ = 0

DEL$\underline{V}$ = 0

Proceed to "SLEEPIE$_d$"

SLEEPIE$_d$

If WANGT > 0:

Perform "EARTHR*"

Perform "CHKCOMED"

Inhibit interrupts

TS = GTSWTLT1 - TIME1

If TS > 0:

TS = TS - 163.83 seconds (should be 163.84)

TS = TS + 1SECXT1

If TS $\leq$ 0:

TS = 0.04 seconds

Call "ALLOOP$_d$" in TS seconds

Release interrupts

End of job

<u>$ALLOOP_d$</u>

GTSWTLT1 = TIME1

TS = ALTIM

Set restart grp. 5 to cause restart at next line

If TS = +0:

  ALTIMS = +0

  ALTIM = -0

If TS = -0:

  ALTIM = +0

If TS $<$ 0: (should not be positive non-zero)

  ALTIM = - (|ALTIM| - 1) (if was -1, result is -0)

Set $DEL\underline{V}_{sp}$ = $PIP\underline{A}$ and $PIP\underline{A}$ = +0 (no special restart provisions)

Set restart group 5 to cause restart at next line

Establish "$ALFLT_d$" (priority 22_8)

End of task

<u>$ALFLT_d$</u>

$T\underline{S} = DEL\underline{V} \left[X_{sm}\right]$

$DPIPAY = - TS_y$

$DPIPAZ = TS_z$

If ALTIMS $\geq$ 0:

  TS = 144 - ALX1S

  $ALTIM = ALFDK_{TS}$ (for T seconds, set to -(T - 2))

  $ALTIMS = ALFDK_{TS+1}$ (e.g. set to -1)

  $BUFTCPIP = ALFDK_{TS+2}$ ("a_1")

  $BUFTCERC = ALFDK_{TS+4}$ ("a_2")

(If ALTIMS $\geqslant$ 0):

$BUFSLPAZ = ALFDK_{TS+6}$ ("a_3")

$BUFSLPVRD = ALFDK_{TS+8}$ ("a_4")

$BUFSLPNSD = ALFDK_{TS+10}$ ("a_5")

$ALX1S = ALX1S - 12$

$INTY = INTY - K_{pipasc}\ DPIPAY$ (i.e. "po_s", south PIPA)

$DELM_y = K_{vesc}\ VLAUN_y - INTY$ ("ΔM_1")

$INTZ = INTZ - K_{pipasc}\ DPIPAZ$ ("po_e", east PIPA)

$DELM_z = K_{vesc}\ VLAUN_z - INTZ$ ("ΔM_2")

$KGAINPIP = BUFTCPIP\ KGAINPIP$ ("K_1")

$KGAINERC = BUFTCERC\ KGAINERC$ ("K_2")

$INTY = INTY + KGAINPIP\ DELM_y$ ("po_s") (tag "AIKLP")

$KGAINAZ = KGAINAZ + BUFSLPAZ$ ("K_3")

$ANGX = ANGX + 4\ KGAINAZ\ DELM_y$ ("alpha")

$VLAUN_y = VLAUN_y + K_{ask0}\ DELM_y$ ("v_{ls}")

$ANGZ = ANGZ + KGAINERC\ DELM_y$ ("gamma") (tag "AIKLP")

$KGAINVRD = KGAINVRD + BUFSLPVRD$ ("K_4")

$DRIFTO = DRIFTO + 4\ KGAINVRD\ DELM_y$ ("d_x")

$ACCWD_y = ACCWD_y + K_{ask2}\ DELM_y$ ("a_s")

$INTZ = INTZ + KGAINPIP\ DELM_z$ ("po_e") (tag "AIKLP")

$KGAINNSD = KGAINNSD + BUFSLPNSD$ ("K_5")

$DRIFTI = DRIFTI + 4\ KGAINNSD\ DELM_z$ ("d_y")

$VLAUN_z = VLAUN_z + K_{ask0}\ DELM_z$ ("v_{le}")

$ANGY = ANGY + KGAINERC\ DELM_z$ ("beta") (tag "AIKLP")

$ACCWD_z = ACCWD_z + K_{ask2}\ DELM_z$ ("a_e") (for indexing, a dummy "K_6", value 0, is generated)

$\underline{TS} = [TRANSM1]\ (POSNV_y,\ VLAUN_y,\ ACCWD_y)$ (tag "LOOSE")

$(POSNV_y,\ VLAUN_y,\ ACCWD_y) = \underline{TS}$

$\underline{TS} = [TRANSM1]\ (POSNV_z,\ VLAUN_z,\ ACCWD_z)$

($POSNV_z$, $VLAUN_z$, $ACCWD_z$) = $T\underline{S}$

SNANGi = sin K_{georgj} ANGi   (i = X,Y,Z)

CSANGi = cos K_{georgj} ANGi   (i = X,Y,Z)

Proceed to erasable memory cell 3400_8 (E7,1400)

NOTE: Following coding was in earlier programs (Sundisk) and is supplied for continuity purposes <u>only</u>. Fixed memory information is at "ONCEMORE" and onward.

INTY = INTY + SNANGZ   ("po_s")

INTZ = INTZ + SNANGY CSANGZ   ("po_e")

WPLATO = DRIFTO - WANGO (CSANGY CSANGZ) - WANGI (SNANGX SNANGY + CSANGX CSANGY SNANGZ)

WPLATI = WANGT WANGI + WANGO SNANGZ + DRIFTI - WANGI CSANGX CSANGZ

WPLATT = DRIFTT - WANGO SNANGY CSANGZ + WANGI (SNANGX CSANGY - CSANGX SNANGY SNANGZ)

TS = (WPLATO CSANGY + WPLATT SNANGY)/ CSANGZ

WPLATi (i = O,I,T) are x,y,z components of $\underline{W}_{sm}$

ANGX = ANGX + K_{georgk} TS

ANGY = ANGY + K_{georgk} (WPLATI + TS SNANGZ)

ANGZ = ANGZ + K_{georgk} (WPLATT CSANGY - WPLATO SNANGY)

If overflow has taken place since start of job:

Proceed to "SOMEERRR"

NOTE: This ends coding taken from earlier programs (Sundisk); presumably the erasable coding now transfers to "ONCEMORE"

<u>ONCEMORE</u>

If LENGTHOT > 0:

LENGTHOT = LENGTHOT - 1

Proceed to "$SLEEPIE_d$"

If WANGT > 0:

LOSVC2 = CDU_x

$OG\underline{C} = \left[X_{sm}\right] (-K_{georgj})$ (ANGX, ANGY, ANGZ)

TS = "OGC"

Perform "IMUPULSE"

Perform "IMUSTALL": if error return, proceed to "SOMERR2"
otherwise, proceed

If WANGT > 0:

Proceed to "VALMIS"

$\underline{ERVECTOR} = K_{omegms}(\sin C_{atd}, -\cos C_{atd}, 0)$

$T_{mark} = T_{now}$

$\underline{ERCOMP} = 0$

Proceed to "TORQUE"

<u>SOMEERRR</u>

Perform "ALARM" (pattern 1600_8)

Proceed to second line of "SOMERR2"

<u>TORQUE</u>

DSPTEM2 = 0 (forces R1 of N98 = 0)

$DSPTEM2+1 = DRIFTI_{sp}$

TS = POSITON - 1

$SOUTHDR_{TS} = DRIFTI_{sp}$

Perform "SHOW"

Proceed to "PIPACHK"

<u>PIPACHK</u>

Proceed to erasable memory cell 2000_8 (E4,1400)

<u>VALMIS</u>

$DSPTEM2+1 = DRIFTO_{sp}$

DSPTEM2+0 = 0 (forces R1 of N98 = 0)

Perform "SHOW"

Proceed to second line of "SOMERR2"

SHOW

DSPTEM2+2 = POSITON

TS = 0698_{vn}

Proceed to "GOFLASH": if terminate, proceed to 2nd line of "SOMERR2"
if proceed, proceed
otherwise, proceed to "SHOW"

Return

Quantities in Computations

See also list of major variables and list of routines

1dPIPADT: See IMU Computations.

1SECXT1: See Prelaunch Alignment (set to 1 second for gyro drift determination).

$ACCWD_y$, $ACCWD_z$: Value of "horizontal acceleration of launch vehicle" (due to sway) in north-south and east-west directions respectively, scale factor B9, units cm/sec^2.

$ALFDK_i$: Table of erasable memory quantities used in "$ALFLT_d$" to update values of parameters to be used for filtering in gyro drift computations. The table consists of five double precision constants, one single precision constant (the setting for ALTIM), and a reset value of ALTIMS (which could be e.g. -1 for all tables). Values must be initialized by an erasable memory load(with the first value at "ALFDK", octal cell 2022_8), with settings for ALTIM, ALTIMS, BUFTCPIP, BUFTCERC, BUFSLPAZ, BUFSLPVRD, and BUFSLPNSD stored in that order (first two single precision, remainder double precision). Scale factor of first two assumed B14, and the remainder assumed B0, in this writeup. See below for "typical" values (obtained from Sundisk program, when information was in fixed memory).

ALMCADR: See General Program Control.

ALTIM: Single precision value of time remaining prior to change in filter constants for drift measurements, scale factor B14, units seconds. To cause a set of gains to be used for T seconds, ALTIM is set to - (T - 2).

ALTIMS: Single precision flag cell set to 0 when a gain change should be made (see ALTIM), and then reset (e.g. to -1) when the gain change has been done, scale factor B14.

ALX1S: Single precision cell, scale factor B14, used to control selection of values from $ALFDK_i$ erasable memory table (set to 144 in "$ESTIMS_d$").

ANGX, ANGY, ANGZ: Values of determined angle changes about vertical, south, and east axes respectively, scale factor B0, units revolutions: they are "azimuth alignment angle","south axis leveling angle", and "east axis leveling angle" respectively (alpha, beta, gamma in official equation documentation).

BUFSLPAZ, BUFSLPNSD, BUFSLPVRD: Set of buffer cells used to contain the values of the slopes of the gains for azimuth angle, north-south drift, and vertical drift respectively, scale factor B0, read from ALFDK table set. Cells are ALDK+4, ALDK+8, and ALDK+6 respectively.

BUFTCERC, BUFTCPIP: Set of buffer cells used to contain the values of the "time constants" for the erection angles ("east axis leveling angle" and PIPA outputs, scale factor B0, as read from ALFDK table set. Cells are ALDK+2 and ALDK.

C_{atd}: See Prelaunch Alignment.

C_{azmth}: See Prelaunch Alignment.

CMPX1: Single precision cell, scale factor B14, used to set proper contents of index register X1 to permit use of an index loop (X1 is set successively to $\pm$ 1) to perform calculations in "$ALFLT_d$": use of the cell is not shown in this writeup.

CSANGi (i = X,Y,Z): Values of cosine of ANGX, ANGY, and ANGZ, scale factor B1, stored in push-down list locations 16D, 18D, and 20D respectively.

$DELM_y$, $DELM_z$: Value of measurement quantity in south and easterly directions used in drift test, scale factor B-2, units radians.

DPIPAY, DPIPAZ: See Prelaunch Alignment.

DRIFTI: Value of gyro drift measurement output displayed in "TORQUE", scale factor (assumed) B0, units "radians", giving the "south gyro drift".

DRIFTO: Value of gyro drift measurement output displayed in "VALMIS", scale factor (assumed) B0, units "radians", giving the "vertical gyro drift".

DRIFTT: Input "drift" to gyro drift determination routine (to separate "east gyro drift" from "azimuth error"), scale factor B0, units radians. It has only its most significant half loaded by calling routines, with the least significant half set 0.

EBANK: See Data Input/Output.

ERCOMP: See Prelaunch Alignment.

ERCOUNT: Single precision cell, scale factor B14, used to count the number of errors encountered in the self-check routine. The cell is initialized to 0 as part of a verb 36 fresh start, and may be read as the third component of noun 08.

ERESTORE: Single precision cell, initialized to 0 as part of a fresh start, used for control purposes in functions associated with the erasable memory checking ("ERASLOOP") portion of the self-check program. It is set to the S-register portion of the lower of the two erasable memory cells being checked (the same as SKEEP7) before these cells are altered. If a restart is encountered, the "GOPROG" routine checks that bits 15-11 of the word are zero (i.e. it is less than 2000_8, as required for erasable memory cells), and that it is equal to SKEEP7 (assuming, of course, the word in non-zero). Both conditions must be satisfied before SKEEP4 (for EBANK) and SKEEP7 address information are used to restore the cells; if one is not, then a fresh start is performed. Since

the ERESTORE cell (address 1360_8) is subject to erasable memory cell checks, when it does not necessarily contain the same data as SKEEP7, a fresh start may be forced even though SKEEP4 and SKEEP7 (neither of these cells are used for change purposes in the erasable memory check routine, since upper limit is 1373_8) is sufficient to permit restoration of erasable memory contents.

ERVECTOR: See Prelaunch Alignment.

FBANK: Hardware register cell (address 0004_8) used to contain the fixed memory bank number (if in range 30_8 - 37_8, FEXT is also used). See 3420.5-27 for details (only bits 15-11 are used).

FEXT: Computer hardware channel (channel 07, also referred to as SUPERBNK) used to select the appropriate fixed-memory bank for FBANK settings of 30_8 or more. Only bits 7-5 are used, with a setting of 3 selecting banks 3i; a setting of 4 selecting banks 4i (bank 43 is the last one in the computer). See 3420.5-27 for details.

GCOMP: See IMU Computations.

GCOMPSW: See IMU Computations.

GEOCOMP1: See Prelaunch Alignment. Set to +0 to indicate gyro drift measurement, but this logic not shown in this writeup. Instead, the zero-value case is in this writeup and the non-zero case in Prelaunch Alignment.

GTSWTLT1: See Prelaunch Alignment.

INTY, INTZ: Value of filtered accelerometer output (corrected for vehicle sway etc.) used in gyro drift test, scale factor B-2, units radians. Could also be considered to be "south" and "east" velocity increments expressed in units of g's (see K_{pipasc}).

K_{ask0}: Constant, program notation "ALSK", scale factor B12, value 0.17329931. Value corresponds to 0.72402338 x 980.402 x 2^{-12}, where first term is "wind-induced sway velocity gain" (official equation documentation notation "K_7"), second converts DELM to units of cm/sec (i.e. units of VLAUN, cf. K_{pipasc}), and third term is scale factor.

K_{ask2}: Constant, program notation "ALSK +2", scale factor B12, value -0.00835370. Value corresponds to 0.03490074 x (-1) x 980.402 x 2^{-12}, where first term is "wind-induced sway accelerometer gain" (official equation documentation notation "K_8"), second is an equation factor, third converts to units of cm/sec^2 (cf. K_{pipasc}), and fourth term is scale factor.

K_{georgj}: Constant, program notation "GEORGEJ", scale factor B-2, value 0.63661977. Value corresponds to $(1/2\pi) \times 2^2$, to convert between radians and revolutions (the interpretive language trig functions require angle measurements in revolutions).

K_{georgk}: Constant formerly incorporated in fixed memory for use in IMU calibration computations. Value was 0.59737013, scale factor B-13. This corresponded to about $7.2921158E-5 \times 2^{13}$, where first term is earth rate in rad/sec (period of about 86164.0912 seconds).

K_{omegms}: See Prelaunch Alignment.

K_{pipasc}: Constant, program notation "PIPASC", scale factor B-7, value 0.76376833. Value corresponds to $5.85 \times (1/980.402) \times 2^7$, where first term is nominal accelerometer scale factor (cm/sec per count), second is normalization factor (acceleration due to gravity), and third is scale factor. For convenience in description, a fourth factor of "1/second" has been assumed reflected in this constant, giving for units of result (in INTY etc.) "radians".

K_{soupy0}: Constant, program notation "SOUPLY", scale factor B0, used in "$ESTIMS_d$" to initialize KGAINPIP. Value is 0.93505870.

K_{soupy2}: Constant, program notation "SOUPLY +2", scale factor B2, used in "$ESTIMS_d$" to initialize KGAINERC. Value is 0.26266423, corresponding to a "true value" of about 1.05065692.

K_{stbnk}: Single precision constant, program notation "LSTBNKCH", octal value 66100_8, corresponding to an FBANK value (bits 15-11) of 33_8 and an FEXT value (bits 7-5) of 4, i.e. a final "bank" readout of bank 43_8, the final computer hardware fixed memory bank.

K_{vesc}: Constant, program notation "VELSC", scale factor B-9, value -0.52223476. Value corresponds to $(-1) \times (1/980.402) \times 2^9$, where first term is an equation factor, second converts for acceleration due to gravity (cf. K_{pipasc}), and third is scale factor.

KGAINAZ, KGAINERC, KGAINNSD, KGAINPIP, KGAINVRD: Values of gains updated each cycle in gyro drift determination computations. KGAINERC and KGAINPIP are initialized to non-zero values in "$ESTIMS_d$" and multiplied by "time constants" for "erection angles" and "PIPA outputs" respectively, with scale factors due to initialization of B2 (KGAINERC) and B0. The others (KGAINAZ, KGAINNSD, and KGAINVRD) are initialized to 0 values in "$ESTIMS_d$", and are incremented each cycle to achieve varying gains for "azimuth angle", "north-south drift", and "vertical drift" respectively: all are considered to have scale factor B0 (see ALFDK). Program notation for the quantities is ALK+4, ALK+2, ALK+8, ALK+0, and ALK+6 respectively.

LENGTHOT: Single precision cell, scale factor B14, used to contain time duration information. Initialization must be done as part of erasable memory pre-load (in Prelaunch Alignment is initialized by coding).

LOSVC2: Single precision cell, program notation "LOSVEC +1", scale factor B-1, units revolutions, loaded with CDU_x in "ONCEMORE".

NDXCTR: Single precision cell, scale factor B14, initialized to 0 in "GEOIMUTT" and incremented to 1 for a "gimbal lock" return from "CALCGA" (angle of 60° or more).

NEWJOB: See General Program Control.

OGC: See Coordinate Transformations (used also as communication cell).

PERFDLAY: See Prelaunch Alignment (for gyro drift test, must be set manually to some value).

PIPA: See IMU Computations.

POSITON: Single precision cell, scale factor B14, used for indexing and display purposes (used in previous programs to select desired stable member orientation from fixed memory information). Must be loaded manually (inputs in "SHOW" do not change it).

$POSNV_y$, $POSNV_z$: Values of "horizontal displacement of launch vehicle" in south and east directions respectively, assumed scale factor B9, units cm ("assumed" since scaling of [TRANSM1] elements not known, but treated as B1).

SCOUNT, SCOUNT+1: Pair of single precision counters, scale factor B14, used to count the number of executions of portions of the self-check program. SCOUNT is incremented each time "SMODECHK" is entered with SMODE $\neq$ +0 and with magnitude below 9; SCOUNT+1 is incremented each time "ERASLOOP" is completed (at the end of the test). Both quantities are modulo 2^{14}, and would have to be initialized manually since they are not preset as part of a fresh start (V36E), if a "true count" were desired. A value of SCOUNT = 3 (if set 0 before SMODE made e.g. 1) means that the self-test erasable and fixed memory checks have been completed. Addresses are 1366_8 and 1367_8 respectively.

SELFRET: See General Program Control.

SFAIL: Single precision cell used in "ERRORS" routine to retain return address information (and hence data on the cause of the self-check difficulty). Contains the same information as ALMCADR if no subsequent alarms (from sources other than self-check) are generated; it is not preset 0 by program unless error reset input.

SKEEP1: Self-check register #1, used to retain return address information from "SMODECHK" and the value of the bank sum while being formed. If the "SHOWSUM" option (V91E) is used, it contains the value of the sum as displayed in R1 (can be either + or -, and if + should be equal to the bank number; if minus should be the complement of the bank number). If self-check memory verification is done, is replaced by the magnitude of the sum before checking against the bank number.

SKEEP2: Self-check register #2, used in erasable memory check routine as a flag (if non-zero) to cause unswitched erasable to be checked (cells 0061_8 - 1372_8, plus 1373_8 partially) after completion of checks for each erasable bank (these cells are in banks 0-2, which should be read for any value of EBANK). Cell is used in fixed memory check routine to contain the contents of the fixed memory cell just read; in the "SHOWSUM" option, it contains the fixed memory bank number (00 - 43_8) displayed in R2, which should be the same as the magnitude of SKEEP1 (value of SKEEP1 is displayed in R1).

SKEEP3: Self-check register #3, used in erasable memory check routine to contain the value of the last address to be checked (i.e. one more than the final value of SKEEP7 actually used). The routine checks cells in pairs in ascending order (starting with the cell initialized in SKEEP7), and SKEEP3 specifies the final cell forming the upper half of a pair (SKEEP7 +1). Cell is used in fixed memory check to contain for fixed-fixed memory the S-register information (4000_8 - 7777_8), and for fixed-switchable memory the S-register information decreased by 2000_8. For the "SHOWSUM" option, cell is loaded with the final value of SKEEP2, which gives the final word read from memory (the "bugger word", designed to make the sum of all words in the memory, including itself, equal in magnitude to the bank number) for the bank, and is displayed in R3.

SKEEP4: Self-check register #4, used in erasable memory check routine to contain the erasable memory bank of the cells being checked (employed in "GOPROG" to reset EBANK, cf. ERESTORE). In fixed memory check routine, bits 15-11 are used to contain the appropriate setting for FBANK and bits 7-5 the appropriate value for FEXT.

SKEEP5: Self-check register #5, used with SKEEP6 in erasable memory check routine to retain the previous value of the cell being checked (to permit restoration of the cell in "GOPROG" or at the end of the test segment checking the cell). Used in fixed memory check routine to monitor for the presence of two TC self ("transfer control to the present step") orders, indicating that the following cell should be the final one entering the sum (bank sum also halted after last cell in bank has been read). If step not a TC self, SKEEP5 set to +1; if it is, cell is decreased by 1, and after reaching -1 the routine is halted for that bank after the next ("bugger", see SKEEP3) word is incorporated into the sum. Since the operation code for the TC order is 0, a "TC self" instruction (which, of course, would cause a hardware restart if encountered in the course of a program execution) appears as $0AAAA_8$, where AAAA is the S-register address of the cell in question, in range 2000_8 - 7777_8.

SKEEP6: Self-check register #6, used with SKEEP5 in erasable memory check routine to retain the previous value of the upper half of the pair of cells being checked (cf. SKEEP5). In the fixed memory check routine, is set to -0 to indicate that the "ROPECHK" option is used (automatic check for proper memory sum, part of self-check sequence, with no display unless difficulty); and is set to +1 to indicate that the "SHOWSUM" option is used (enabled by verb 91 from "GOSHOSUM", giving a DSKY display of each bank's sum, number, and "bugger word", with no automatic check for proper memory sum).

SKEEP7: Self check register #7, used in erasable memory check routine to contain the S-register portion of the erasable memory address of the lower half of the pair of cells being checked (see discussion with ERESTORE above). In fixed memory check, is used as an identification of when the two fixed-fixed banks (bank 2 and bank 3, S-register addresses starting at 4000_8 and 6000_8 respectively) are to be read.

SMODE: Single precision cell, scale factor B14, used to control the performance of the computer self-check routines, and examined whenever no active jobs are to be done (and, of course, no tasks). It is set to +0 as part of a fresh start, and can be loaded using N27. A +0 value causes the self-check routine to be bypassed; values of magnitude 9 or more cause SMODE to be reset to 0; a value of 4 causes the erasable memory check to be done; a value of 5 causes the fixed memory check to be done; and other values (-0, 1,2,3,6,7, or 8) cause the complete self-check to be done. If SMODE is positive, an error will cause it to be reset 0, while if it is negative the self-check will be started again (except for a value of -0, which causes the self-check computations to be started at the point after the failure, as determined by SFAIL).

SNANGi (i = X,Y,Z): Value of sine of ANGX, ANGY, and ANGZ, scale factor B-2, stored in push-down list locations 10D, 12D, and 14D respectively.

SOUTHDR_i: Indexed cell used in "TORQUE" to retain the value of DRIFTI_{sp} for subsequent use by erasable memory program.

T_{mark}: See Prelaunch Alignment.

[TRANSM1] : Transformation matrix used as a "sway transition matrix", contained in erasable memory (must be initialized to values as part of an erasable memory load before running test). Assumed scaling in this writeup for all elements is B1 (after being used to perform multiplication, a left shift of 1 is done). Values from a previous program (Sundisk, which used fixed memory cells) were:

$$\begin{bmatrix} 0.47408845 & 0.23125894 & 0.14561689 \\ -0.06360691 & -0.16806746 & 0.15582939 \\ -0.06806784 & -0.75079894 & -0.24878704 \end{bmatrix}$$

These values are the "stored" ones, and must be multiplied by two to find the "true" values:

$$\begin{bmatrix} 0.94817690 & 0.46251788 & 0.29123378 \\ -0.12721382 & -0.33613492 & 0.31165878 \\ -0.13613568 & -1.50159788 & -0.49757408 \end{bmatrix}$$

$VLAUN_y$, $VLAUN_z$: Value of "horizontal velocity of launch vehicle" (due to sway) in north-south and east-west directions respectively, scale factor B9, units cm/sec.

WANGI: Value of ($- \cos C_{atd}$), scale factor BO.

WANGO: Value of ($\sin C_{atd}$), scale factor BO.

WANGT: Quantity set to 0 if no torquing is performed and to 1 (scale factor BO) if torquing is to be performed via "EARTHR*" at the start of "$SLEEPIE_d$". Program notation also "TORQNDX, TORQNDX+1". If it is non-zero, WANGI term is included in computation of WPLATI.

WPLATI, WPLATO, WPLATT: Quantities computed in "$AlFLT_d$", scale factor BO, normalized by earth rotation rate (hence are converted to angles, for the one-second gyro drift evaluation cycle, by multiplication by K_{georgk}). The "I" is south, the "O" is vertical ("azimuth"), and the "T" is east.

Values of ALFDK information from an earlier program (Sundisk)

Index	Time	ALTIM	BUFTCPIP	BUFTCERC	BUFSLPAZ	BUFSLPVRD	BUFSLPNSD
0	1-30	-28	.91230833	.81193187	-.00035882	-.00000029	.00013262
12	31-90	-58	.99122133	.98940595	-.00079010	-.00000265	.00043154
24	91-100	-8	.99971021	.99852047	.00042697	-.00000213	.00011864
36	101-200	-98	.99550063	.98992124	.00043452	-.00000401	-.00021980
48	201-450	-248	.99673264	.99365467	.00003767	-.00002317	-.00003305
60	451-790	-338	.99924362	.99888274	.00000064	-.00004012	-.00000195
72	791-1200	-408	.99963845	.99913162	.00000090	.00002927	-.00000026
84	1201-1700	-498	.99934865	.99868793	.00000055	.00001183	-.00000005
96	1701-2100	-398	.99947099	.99894799	.00000018	.00000300	-.00000001
108	2101-2700	-598	.99957801	.99916095	.00000007	.00000096	0
120	2701-3400	-698	.99966814	.99933952	.00000002	.00000028	0
132	3401-4000	-598	.99972716	.99945654	.00000001	.00000010	0

The "index" column gives the value of the ALFDK index required to obtain the ALTIM setting (see "ALFLT$_d$"). The columns are headed with the cells into which the ALFDK$_i$ information is loaded (ALTIMS, a single precision cell, could be loaded with the same value, e.g. -1, for all entries to the table).

Uplink Processing

V70UPDAT (verb 70)

UPVERBSV = 0

Proceed to second line of "V73UPDAT"

V71UPDAT (verb 71)

UPVERBSV = 1

Proceed to second line of "V73UPDAT"

V72UPDAT (verb 72)

UPVERBSV = 2

Proceed to second line of "V73UPDAT"

V73UPDAT (verb 73)

UPVERBSV = 3

Perform "TESTXACT"

If $|MODREG| \neq 0$:

If bit 9(UTFLAG) of FLAGWRD8 = 1:

If MODREG = 20:

Proceed to "UPDATEOK"

If MODREG $\neq$ 2:

Set bit 7(Operator error) of channel 11 = 1

Set bit 3(Uplink activity) of channel 11 = 0

Proceed to "ENDEXT"

Proceed to "UPDATEOK"

UPDATEOK

UPOLDMOD = MODREG

UPVERB = UPVERBSV

UPCOUNT = 1

DNLSTCOD = 1 (Tag here "UPPART2")

TS = 27 and perform "NEWMODEX"

If UPVERB = 0 or 3:

COMPNUMB = 2

Proceed to "OHWELL2"

Proceed to "OHWELL1"

<u>OHWELL1</u>

MPAC+2 = "UPBUFF"

TS = 2101_{vn}

Proceed to "GOXDSPF": if terminate, proceed to second line of "UPOUT"
if proceed, proceed to second line of "OHWELL1"
otherwise, proceed

If MPAC+0 = 32, proceed to second line of "OHWELL1" (recycle verb)

If UPBUFF - 2 $\leq$ 0, proceed to second line of "OHWELL1"

If UPBUFF - 21 $\not>$ 0, proceed to second line of "OHWELL1"

COMPNUMB = UPBUFF+0

UPCOUNT = UPCOUNT +1

Proceed to "OHWELL2"

<u>OHWELL2</u>

MPAC+2 = "UPBUFF" + UPCOUNT - 1

TS = 2101_{vn}

Proceed to "GOXDSPF": if terminate, proceed to second line of "UPOUT"
if proceed, proceed to second line of "OHWELL2"
otherwise, proceed

If MPAC+0 = 32, proceed to second line of "OHWELL2" (recycle verb)

If COMPNUMB - UPCOUNT > 0:

UPCOUNT = UPCOUNT + 1

Proceed to "OHWELL2"

Proceed to "UPVERIFY"

UPVERIFY

MPAC+2 = "UPTEMP"

TS = 2102_{vn}

Proceed to "GOXDSPF": if terminate, proceed to second line of "UPOUT"
if proceed, proceed to "UPSTORE"
otherwise, proceed

If MPAC+0 = 32, proceed to second line of "UPVERIFY" (recycle verb)

If UPTEMP $\leqslant$ 0, proceed to "UPVERIFY"

If COMPNUMB + 1 - UPTEMP $\leqslant$ 0, proceed to "UPVERIFY"

MPAC+2 = "UPBUFF" + UPTEMP - 1

Proceed to second line of "OHWELL2"

UPSTORE

Complement bit 3(VERIFLAG) of FLAGWRD7

If UPVERB $\geqslant$ 3:

UPBUFF+8_{dp} = UPBUFF+0_{dp}

Perform "TIMEDIDL": if error return, proceed
otherwise, skip next line

Set bit 7(Operator error) of channel 11 = 1

Proceed to second line of "UPOUT"

Establish "UPJOB" (priority 30_8) (has a VAC area for "INTSTALL")

End of job

UPJOB

Perform "INTSTALL"

Set bit 13(INTGRAB) of FLGWRD10 = 1

If UPVERB = 0:

UPBUFF+8_{dp} = - UPBUFF+0_{dp}

(If UPVERB = 0):

Perform "TIMEDIDL": if error return, proceed
otherwise, skip next 2 lines

Set bit 7 (Operator error) of channel 11 = 1

Proceed to "UPOUT"

$UPBUFF+10_{dp} = - UPBUFF+0_{dp}$

$UPBUFF+12_{dp} = - UPBUFF+0_{dp}$

Set $TS = UPBUFF+10_{dp}$ and $UPBUFF+10_{dp} = 0$

$T_{etcm} = T_{etcm} + TS$

Set $TS = UPBUFF+12_{dp}$ and $UPBUFF+12_{dp} = 0$

$T_{etlm} = T_{etlm} + TS$

Set $TS = UPBUFF+0_{dp}$ and $UPBUFF+0_{dp} = 0$

$T_{eph} = T_{eph} + TS$

Proceed to "UPOUT"

If UPVERB = 1:

EBANK = bits 11-9 of UPBUFF+1

UPTEMP = bits 8-1 of UPBUFF+1

TS = UPTEMP + COMPNUMB - 3

If $|TS| > 0$:

If bit 9 of TS = 1: (e.g $\geq 400_8$, indicating next EBANK)

Set bit 7 (Operator error) of channel 11 = 1

Proceed to "UPOUT"

TS = COMPNUMB - 3

$TS_1 = 1400_8 + UPTEMP$

Perform the following for i = TS to i = 0: (interrupts inhibited)

$E_{TS_1+i} = UPBUFF_{2+i}$

i = i - 1

Proceed to "UPOUT"

If UPVERB = 2: (as it will)

If bit 1 of COMPNUMB = 0: (i.e. not an odd number)

Set bit 7 (Operator error) of channel 11 = 1

Proceed to "UPOUT"

TS = COMPNUMB - 2

Perform the following for i = TS to i = 1: (interrupts inhibited)

EBANK = bits 11-9 of $UPBUFF_i$

$TS_1 = 1400_8$ + bits 8-1 of $UPBUFF_i$

$E_{TS_1} = UPBUFF_{1+i}$

i = i -2

Proceed to "UPOUT"

TIMEDIDL

Set $UPBUFF{+}18_{dp} = T_{now}$ and $T_{now} = 0$

Set TS = $UPBUFF{+}8_{dp}$ and $UPBUFF{+}8_{dp} = 0$

TS = TS + $UPBUFF{+}18_{dp}$

If $|TS| \ngtr 2^{28}$:

Set TS = $UPBUFF{+}18_{dp}$ and $UPBUFF{+}18_{dp} = 0$

$T_{now} = T_{now} + TS$

Return to calling address +1 (indicating an error)

Force sign agreement of TS

$T_{now} = T_{now} + TS$

Return to calling address +2 (non-error return)

UPOUT

Proceed to "INTWAKEU" (which exits to next line)

TS = UPOLDMOD and perform "NEWMODEX"

TS = MODREG - 1

If |TS| = 1: (i.e. UPOLDMOD was 0 or 2)

DNLSTCOD = 0

If TS > 1: (i.e. UPOLDMOD was 20)

DNLSTCOD = 2

Set bit 3(Uplink activity) of channel 11 = 0

Proceed to "ENDEXT"

INTWAKEU

If UPSVFLAG ≠ 0:

$RC\underline{V} = \underline{R}_{rect}$

$VC\underline{V} = \underline{V}_{rect}$

$TDELTA\underline{V} = 0$

$TNU\underline{V} = 0$

$T_c = 0$

XKEP = 0

TS = |UPSVFLAG| - 2

If TS = 0:

X2 = 2 (moon sphere)

Set bit 12(MOONFLAG) of FLAGWRD0 = 1

If TS ≠ 0:

X2 = 0

Set bit 12(MOONFLAG) of FLAGWRD0 = 0

If UPSVFLAG > 0:

Perform "MOVEACSM"

Set bit 12(CMOONFLG) of FLAGWRD8 = 1

If bit 1(AVEMIDSW) of FLAGWRD9 = 0:

$\underline{R} = RC\underline{V} + TDELTA\underline{V}$ (X2 used to determine

$\underline{V} = VC\underline{V} + TNU\underline{V}$ necessary shifts)

$T_{pptm} = T_{et}$

If bit 12(MOONFLAG) of FLAGWRD0 = 0:

Set bit 12(CMOONFLG) of FLAGWRD8 = 0

Set bit 6(ORBWFLAG) of FLAGWRD3 = 0

(If UPSVFLAG $\neq$ 0):

If UPSVFLAG < 0:

Perform "MOVEALEM"

Set bit 11(LMOONFLG) of FLAGWRD8 = 1

$\underline{R}_{other}$ = RC$\underline{V}$ + TDELTA$\underline{V}$ (X2 used to determine

$\underline{V}_{other}$ = VC$\underline{V}$ + TNU$\underline{V}$ necessary shifts)

If bit 12(MOONFLAG) of FLAGWRD0 = 0: (Time tag T_{etlm})

Set bit 11(LMOONFLG) of FLAGWRD8 = 0

Set bit 1(RENDWFLG) of FLAGWRD5 = 0 (Tag here "INTWAKEX")

Channel 77 = 0 (resets restart monitor flip-flops)

UPSVFLAG = 0

QPRET = Return address (to line after next)

Perform "INTWAKE" (starting at 3rd from last line, awaken jobs)

Proceed to second line of "UPOUT"

Quantities in Computations

See also list of major variables and list of routines

COMPNUMB: Single precision cell, scale factor B14, containing the total number of uplink data quantities to be sent. It is set to 2 for verbs 70 and 73; for verb 71 it is set to the first data quantity (and hence must be equal to the number of data words +1 (for address of first word) +1 (for its own setting)); for verb 72, it is likewise set to the first data quantity (since each data word is preceded by its address, it therefore must be 2 x data words +1). For verbs 71 and 72, values of COMPNUMB below 3 (the minimum for one data word) or above 20 are rejected: this gives for verb 71 a maximum of 18 single precision data words (or 9 double precision ones, sufficient e.g. for a 3 x 3 matrix), and for verb 72 a maximum of nine single precision data words.

DNLSTCOD: See Telemetry.

EBANK: See Data Input/Output.

MPAC+0: Cell loaded in display routine with the verb that is received (also used for other functions).

MPAC+2: Cell used for communication purposes with display routine, to provide the address into which a quantity (for e.g. noun 01 or 02) is to be loaded (also used for other functions).

QPRET: See Orbital Integration.

$\underline{R}_{other}$, $\underline{R}_{rect}$: See Orbital Integration.

RC$\underline{V}$: See Orbital Integration.

T_c: See Orbital Integration.

T_{eph}: See Boost Computations.

T_{et}, T_{etcm}, T_{etlm}: See Orbital Integration.

TDELTA$\underline{V}$, TNU$\underline{V}$: See Orbital Integration.

UPBUFF: Set of 20 cells (UPBUFF+0 through UPBUFF+19) used to contain the uplinked information as it is received. Also used for temporary storage of time information, after completion of the update sequence, for verbs 70 and 73. Cells are loaded during the entry phase of flight with guidance parameters for telemetry purposes. The address of UPBUFF+0 is 00304_8. The last 18 cells of the UPBUFF set also are used for storage of $[X_{smd}]$: consequently, if it is desired to uplink this preferred IMU alignment for use in P52/P54, this must be the last uplink that is sent before P52/P54 uses the data.

UPCOUNT: Single precision quantity, scale factor B14, containing the serial number of the UPBUFF cell to be loaded next. If cell UPBUFF+n is to be loaded, UPCOUNT = (n +1). When UPCOUNT = COMPNUMB, it is concluded that the basic load has been completed, and the option for "line-by-line" corrections is enabled, during which UPCOUNT does not change.

UPOLDMOD: Single precision cell, scale factor B14, used to contain the value of MODREG when an update verb is received, and used to restore its proper value (-0, 0, 2, or 20) after the end of the update sequence.

UPSVFLAG: Single precision cell, scale factor B14, assigned a cell in erasable memory just before the first component of $\underline{R}_{rect}$, and set by the update loading process to cause proper processing of a state vector update. The cell is checked in "INTWAKEU", and if non-zero it is concluded that a state vector update was done (if positive, a CSM state vector; if negative, a LM state vector), and after processing the cell is reset 0 (which is also the initial condition set in "DOFSTART"). A value of magnitude 2 (i.e. +2 for CSM and -2 for LM) indicates that the state vector is in moon-centered coordinates (with moon-centered scaling); other non-zero values, such as +1 and -1, are interpreted to mean earth-centered coordinates (with earth-centered scaling).

UPTEMP: Single precision cell used for temporary storage purposes. In the "line-by-line" correction mode, it contains the loaded value of the component serial number (defined as for UPCOUNT) into which the correction is to be loaded, scale factor B14. The address of UPTEMP is 00330_8.

UPVERB: Single precision quantity, scale factor B14, containing information on the update verb being performed: for verbs 70-73, it is set to 0-3 respectively.

UPVERBSV: Single precision cell, scale factor B14, used to retain information on the update verb received while a determination is made if it is allowed: if it is, then UPVERBSV is loaded into UPVERB.

$\underline{V}_{other}$, $\underline{V}_{rect}$: See Orbital Integration.

VC$\underline{V}$: See Orbital Integration.

XKEP: See Orbital Integration.

Uses of Update Verbs

Verb 70

Verb 70 could be considered a "liftoff time update". Its transmission format is:

V 70 E XXXXX E XXXXX E   (then V 33 E)

where the "X" information is an octal double precision increment to be added to T_{eph} and subtracted from the computer clock and the state vector times for CSM and LM, scale factor B28, units centi-seconds. If liftoff were sensed 5 seconds late, for example, then the transmission should be:

V 70 E 77777 E 77013 E   (V 33 E) ($- 77013_8 = 764_8 = 500$ cs)

in order to correct the AGC time information to reflect the proper "liftoff time" (note that V70 keeps the sum of T_{eph} and the computer clock constant by changing them in opposite directions). If only the computer clock (T_{now}) is to be updated, then verb 73 could be used.

Verb 71

Verb 71 is used to perform a "contiguous block update". Its transmission format is:

V 71 E ii E AAAA E XXXXX E XXXXX E ... XXXXX E   (V 33 E)

where the "ii" information is the setting for COMPNUMB, and is two more than the number of data words (i.e. number of XXXXX E's +2). The AAAA information is the erasable memory address into which the first XXXXX data word is to be loaded (successive words are loaded into successive cells), and must be sufficiently compatible with the value of ii so as to avoid requiring erasable memory bank switching. AAAA is in ECADR format, meaning that bits 11-9 give the E-bank number and bits 8-1 the address within the bank (which, for hardware reasons, is added to 1400_8 within the program). Since there is no lockout (aside from bank switching constraints) on the value of AAAA, caution must be observed to avoid destroying computer control cells (the "ENDSAFE" lockout present in e.g. Sundisk has been deleted).

Verb 72

Verb 72 is used to perform a "scatter update". Its transmission format is:

V 72 E ii E A_1 A_1 A_1 A_1 E XXXXX E A_2 A_2 A_2 A_2 E XXXXX E ... (V33E)

where the "ii" information is again the setting for COMPNUMB, and is equal to two times the number of data words plus 1 (and hence must be odd, as well as at least 3 and below 21, i.e. maximum 19 here). The A's are specified for each 15-bit word individually, with no constraints imposed by the software on addresses which may be changed.

Verb 73

Verb 73 is used to perform an "octal clock increment" (verb 55 can be used to perform the same function for decimal input of hours, minutes, and centi-seconds), and has the following transmission format:

V 73 E XXXXX E XXXXX E (then V 33 E)

where the "X" information is an octal double precision increment to be added to the computer clock (note that the V70 uplink time is subtracted from the computer clock), scale factor B28, units centi-seconds.

Sample Update Sequences

1. To load the components of [REFSMMAT] (double precision elements, scale factor B1), the following sequence could be used:

V 71 E 24 E 1733 E (COMPNUMB = 20; "REFSMMAT" = 3,1733)

XXXXX E XXXXX E (row 1 column 1)
XXXXX E XXXXX E (row 1 column 2)
etc.
XXXXX E XXXXX E (row 3 column 3)
V 33 E (accept)

2. To load the components of $[X_{smd}]$ (preferred IMU orientation, see Inflight Alignment), the same sequence as in #1 could be used, except that the address instead of being 1733 should be 0306("X_{smd}" = "UPBUFF" +2).

3. To load a CSM state vector update, the following sequence could be used:

V 71 E 21 E 1501 E (COMPNUMB = 17; "UPSVFLAG" = 3,1501)

0000x E	(x = 1 for earth-centered, 2 for moon-centered)
XXXXX E XXXXX E	R_{rect_x}
Y-component	
Z-component	
XXXXX E XXXXX E	V_{rect_x}
Y-component	
Z-component	
XXXXX E XXXXX E	T_{et} value
V 33 E	(accept)

4. To load a LM state vector update, the same sequence as in #3 could be used, except that the UPSVFLAG setting, rather than being 00001 (earth) or 00002 (moon), should be 77776 or 77775 respectively.

5. To load an External Delta-V (P30) update, the following sequence could be used:

V 71 E 12 E 3404 E (COMPNUMB = 10; "DELVLVC" = 7,1404)

XXXXX E XXXXX E DELVLVC$_x$
Y-component
Z-component
XXXXX E XXXXX E T_{ig}
V 33 E (accept)

6. To load an External Delta-V (P30) update for deorbit, the following sequence could be used:

V 71 E 16 E 3400 E (COMPNUMB = 14; "LATSPL" = 7,1400)

XXXXX E XXXXX E LATSPL
XXXXX E XXXXX E LNGSPL
(continue on
as in item #5)

7. To perform an update of merely the entry parameters, the sequence of #6 could be used, stopping after LNGSPL (hence first few quantities would be V 71 E 6 E 3400 E).

8. To load a landing site update, the following sequence could be used:

V 71 E 10 E 2025 E (COMPNUMB = 8; "RLS" = 4,1425)
(see Coordinate Transformations)

XXXXX E XXXXX E RLS$_x$
Y-component
Z-component
V 33 E

9. To load new values for erasable memory constants (such as IMU compensation parameters), see the list of cells in Erasable Memory Prelaunch Load (which is arranged in sequence of increasing addresses).

Verb Definitions

VERBFAN

If (VERBREG - K_{st2cn}) $<$ 0:

Proceed to address specified by $K_{vbt_{VERBREG}}$

TS = VERBREG - K_{st2cn}

Perform "RELDSP"

Proceed to address specified by $K_{st2fn_{TS}}$

ALM/END

Set bit 7(Operator error) of channel 11 = 1

Proceed to "PINBRNCH"

TESTXACT

If EXTVBACT $>$ 0:

Proceed to "ALM/END"

If bits 14(PRIOIDLE), 12(PDSPFLAG), and 7(PROWTKEY) of FLAGWRD4 $\neq$ 0:

Proceed to "ALM/END" (priority display using DSKY)

EXTVBACT = 00024_8 (sets bits 5 and 3 to 1)

TS = -2 and perform "NVSUB": if busy, proceed (blank R1-R3
otherwise, proceed and noun)

Check for new job waiting to be performed, and do it if required

Return

VBTSTLTS (verb 35)

If MODREG $\neq$ 0:

Proceed to "ALM/END"

Inhibit interrupts (released in "DELAYJOB" performance)

Set bit 1(LMPTSTBT) of IMODES33 = 1

Set bits 7(Operator error), 6(Flash), 5(Key Release), 4(Temperature Caution), 3(Uplink Activity), and 1(ISS Warning) of channel 11 = 1

DSPTAB+11 = 00650_8 and flag for output at next opportunity
(bit 9 is Program alarm, bit 8 Tracker alarm, bit 6
Gimbal lock, and bit 4 No attitude) (Note if restart, "GOPROG"
put IMU into coarse align)

Set bit 10(Test DSKY lights) of channel 13 = 1

Set DSPTAB+0 to DSPTAB+10 so that all registers display "8" and
R1, R2, and R3 display plus signs, and flag for output at
next opportunity

NOUT = 11

Delay K_{shots} seconds (by putting job to sleep via "DELAYJOB")

Proceed to "TSTLTS3"

TSTLTS3

Set bits 7, 4, 3, and 1 of channel 11 = 0 (interrupts inhibited
during routine)

Set bit 10 of channel 13 = 0

TS = bit 4(Coarse align) of channel 12

DSPTAB+11 = TS, and flag for output at next opportunity (bit 4 is
No attitude)
(Note that bit 9, Program alarm, set 0 even
if FAILREG+0 $\neq$ 0)

Set bit 1(LMPTSTBT) of IMODES33 = 0

Set bits 13-11 (PIP2FLBT, DNLKFAIL, UPLKFAIL) of IMODES33 = 1

Set bit 15(TLIMBIT) of IMODES30 = 0

Set bits 13, 12, and 10 (IMUFLBIT, ICDUFLBT, PIPAFLBT) of IMODES30 = 1

Set bit 7(OCDUFBIT) of OPTMODES = 1

Establish "DSPMMJB" (priority 30_8)

MONSAVE1 = 40000_8 (sets bit 15 to 1)

Set bit 6(Flash) of channel 11 = 0

Perform "RELDSP"

If CADRSTOR $\neq$ 0:

Proceed to "PINBRNCH"

End of job

VBZERO (verb 40)

If IMUCADR $\neq$ 0:

Proceed to "ALM/END"

Perform "IMUZERO"

Perform "IMUSTALL": if error return, proceed
otherwise, proceed

Proceed to "PINBRNCH"

VBCOARK (verb 41)

If NOUNREG $\neq$ 20: (ICDU)

If NOUNREG $\neq$ 91: (OCDU)

Proceed to "ALM/END"

If NOUNREG = 20:

Perform "TESTXACT" (Tag here "IMUCOARK")

TS = 2522_{vn}

Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
if proceed, proceed
otherwise, proceed

TS = 4100_{vn}

Perform "EXDSPRET"

If IMUCADR $\neq$ 0:

Set bit 7(Operator error) of channel 11 = 1

Proceed to "ENDEXT"

Perform "IMUCOARS"

Perform "IMUSTALL": if error return, proceed
otherwise, proceed

Proceed to "ENDEXT"

If MODREG $\neq$ 0: (N91) (Tag here "OPTCOARK")

Proceed to "ALM/END"

Perform "TESTXACT"

If SWSAMPLE $\leq$ 0: (switch not at computer position)

Set bit 7(Operator error) of channel 11 = 1

Perform "ALARM" (pattern 0115_8)

If OPTIND = -0: (Not expected in view of P00 restriction)

Perform "ALARM" (pattern 0117_8)

Proceed to "ENDEXT"

TS = 2492_{vn}

Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
if proceed, proceed
otherwise, proceed

DESOPTS = SAC (loaded in R1 of N92)

DESOPTT = PAC (loaded in R2 of N92)

TS = 4100_{vn}

Perform "EXDSPRET"

OPTIND = 1

Proceed to "ENDEXT"

IMUFINEK (verb 42)

Perform "TESTXACT"

TS = 2593_{vn}

Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
if proceed, proceed
otherwise, proceed

TS = 4200_{vn}

Perform "EXDSPRET"

If IMUCADR $\neq$ 0:

Set bit 7(Operator error) of channel 11 = 1

Proceed to "ENDEXT"

Perform "IMUFINE"

Perform "IMUSTALL": if error return, proceed to "ENDEXT"
otherwise, proceed

TS = "OGC"

Perform "IMUPULSE"

Perform "IMUSTALL": if error return, proceed
otherwise, proceed

Proceed to "ENDEXT"

IMUATTCK (verb 43)

If MODREG $\neq$ 0, proceed to "AIM/END"

If bits 4-5 (IMU Coarse align, IMU Zero) of channel 12 $\neq 00_2$:

Proceed to "AIM/END"

Perform "CKLFTBTS": if after liftoff, proceed
if before liftoff, skip next line

Perform "TESTXACT"

Set bits 6(Enable CDU IMU Error Counters) and 4 (IMU Coarse Align) of channel 12 = 0

TS = 2522_{vn}

Proceed to "GOXDSPF": if terminate, proceed to "TRMATTCK"
if proceed, proceed
otherwise, proceed

Perform "NEEDLE11"

Perform "NEEDLER2"

Call "ATTCK1" in 0.02 seconds

Proceed to "TRMATTCK"

TRMATTCK

Perform "CKLFTBTS": if after liftoff, proceed to "ENDEXT"
if before liftoff, proceed

Proceed to "PINBRNCH"

ATTCK1

$\underline{AK}$ = $\text{THETA}\underline{\text{D}}$

Perform "NEEDLES"

End of task

CKLFTBTS

If bit 5(BKUPLO) of FLAGWRD5 = 0:

If bit 5(Liftoff complement) of channel 30 = 1:

Return to calling address +2 (before liftoff)

Return to calling address +1 (after liftoff)

SETSURF (verb 44)

Set bit 8(SURFFLAG) of FLAGWRD8 = 1 (used e.g. in "INTEGRV" for selection of LM state vector computational scheme)

Proceed to "PINBRNCH"

RESTSRF (verb 45)

Set bit 8(SURFFLAG) of FLAGWRD8 = 0

Proceed to "PINBRNCH"

STABLISH (verb 46)

See Digital Autopilot Interface Routines

LMTOCMSV (verb 47)

Establish "LMTOCM" (priority 10_8)

End of job

LMTOCM

Perform "INTSTALL"

Set bit 12(CMOONFLG) of FLAGWRD8 = 1

If bit 11(LMOONFLG) of FLAGWRD8 = 0:

Set bit 12(CMOONFLG) of FLAGWRD8 = 0

Inhibit interrupts

$\underline{R}_{rectcm} = \underline{R}_{rectlm}$

$\underline{V}_{rectcm} = \underline{V}_{rectlm}$

$T_{etcm} = T_{etlm}$

$DELTA\underline{V}_{cm} = DELTA\underline{V}_{lm}$

$\underline{NUV}_{cm} = \underline{NUV}_{lm}$

$\underline{RCV}_{cm} = \underline{RCV}_{lm}$

$\underline{VCV}_{cm} = \underline{VCV}_{lm}$

$T_{ccm} = T_{clm}$

$XKEP_{cm} = XKEP_{lm}$

Proceed to "TACHEXIT"

TACHEXIT

Release interrupts
Perform "MOVEPCSM"
If bit 12(CMOONFLG) of FLAGWRD8 = 1:
  Set bit 12(MOONFLAG) of FLAGWRD0 = 1
  PBODY = 2
If bit 12(CMOONFLG) of FLAGWRD8 = 0:
  Set bit 12(MOONFLAG) of FLAGWRD0 = 0
  PBODY = 0

X2 = PBODY

If bit 1(AVEMIDSW) of FLAGWRD9 = 0:

$\underline{R} = RC\underline{V} + TDELTA\underline{V}$ (X2 used to determine

$\underline{V} = VC\underline{V} + TNU\underline{V}$ necessary shifts)

$T_{pptm} = T_{et}$

$\underline{R}_{other} = RC\underline{V} + TDELTA\underline{V}$ (X2 used to determine

$\underline{V}_{other} = VC\underline{V} + TNU\underline{V}$ necessary shifts)

Perform "INTWAKE" (starting at 3rd from last line, awaken jobs)

Proceed to "PINBRNCH"

DAPDISP (verb 48)

See Digital Autopilot Interface Routines

CREWMANU (verb 49)

If MODREG ≠ 0, proceed to "ALM/END"

Perform "TESTXACT"

Establish "R62DISP" (priority 10_8)

End of job

GOLOADLV (verbs 50, 51, 53, 59, 97, and 99)

Set bit 6(Flash) of channel 11 = 0

Proceed to "LOADLV"

V52 (verb 52)

If MODREG $\neq$ 22:

Proceed to "ALM/END"

Set bits 12-10 of LANDMARK = 0

TS = (NUM8NN, shifted left 9 places) (bits 12-10)

LANDMARK = LANDMARK + TS

Proceed to "PINBRNCH"

GOTOR23 (verb 54)

Perform "TESTXACT"

If bit 7(RNDVZFLG) of FLAGWRD0 = 1:

If bit 5(TRACKFLG) of FLAGWRD1 = 1:

Establish "R23CSM" (priority 16_8)

End of job

Perform "ALARM" (pattern 0406_8)

Proceed to "ENDEXT"

ALINTIME (verb 55)

Perform "TESTXACT"

TS = 2524_{vn}

Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
if proceed, proceed to "ENDEXT"
otherwise, proceed

If MPAC+0 $\neq$ 23: (final verb not 23)

Proceed to "ENDEXT"

Inhibit interrupts

Set TS = T_{now} and T_{now} = 0

$TS = TS + DSPTEM2+1_{dp}$, with sign agreement forced ($DSPTEM2+1_{dp}$ contents destroyed)

$T_{now} = T_{now} + TS$

Release interrupts

Proceed to "ENDEXT"

<u>TRACKTRM</u> (verb 56) Also entered from R60 or V34E to V06N49 in P20

Set bit 2(R67FLAG) of FLAGWRD8 = 0

If bit 9(UTFLAG) of FLAGWRD8 = 0:

  If bit 7(RNDVZFLG) of FLAGWRD0 = 0:

    Proceed to "PINBRNCH"

  Set bit 7(AUTOSEQ) of FLGWRD10 = 0

  Set bit 14(R21MARK) of FLAGWRD2 = 0

  Set bit 7(UPDATFLG) of FLAGWRD1 = 0

If bit 5(TRACKFLG) of FLAGWRD1 = 0:

  Set bit 7(RNDVZFLG) of FLAGWRD0 = 0

  Set bit 9(UTFLAG) of FLAGWRD8 = 0

  Proceed to "PINBRNCH"

Set bit 5(TRACKFLG) of FLAGWRD1 = 0

Set bit 8(IMUSE) and bit 7(RNDVZFLG) of FLAGWRD0 = 0

Set bit 9(UTFLAG) of FLAGWRD8 = 0

Perform "INITSUBA"

Perform "INTSTALL"

Make restart groups 1 and 2 inactive

Inhibit interrupts

Proceed to "ENEMA"

<u>V57CALL</u> (verb 57)

Perform "TESTXACT"

OPTIONX = 4

TS = 0

If bit 2(FULTKFLG) of FLGWRD10 = 1: (bit used in "AUTOW", zero means have VHF <u>and</u> optics)

TS = 1

OPTIONX+1 = TS

TS = 0412_{vn}

Proceed to "GOXDSPF": if terminate, proceed to "ENDEXT"
if proceed, proceed to "ENDEXT"
otherwise, proceed

If OPTIONX+1 = 0:

Set bit 2(FULTKFLG) of FLGWRD10 = 0

NOTE that action taken based on data enter, <u>not</u> PRO, giving difficulty for display interruptions

If OPTIONX+1 ≠ 0:

Set bit 2(FULTKFLG) of FLGWRD10 = 1

Proceed to third line of "V57CALL"

<u>ENATMA</u> (verb 58)

Set bit 15(V50N18FL) of FLAGWRD3 = 1

Set bit 14(STIKFLAG) of FLAGWRD1 = 0

Proceed to "PINBRNCH"

<u>V60</u> (verb 60)

CPHI$\underline{X}$ = CD$\underline{U}$

Proceed to "PINBRNCH"

<u>V61</u> (verb 61)

Set bit 9(NEEDLFLG) of FLAGWRD0 = 0 (display DAP error)

Proceed to "PINBRNCH"

<u>V62</u> (verb 62)

Set bit 6(N22ERNDS) of FLAGWRD9 = 1 (display N22 error)

Set bit 9(NEEDLFLG) of FLAGWRD0 = 1

Proceed to "PINBRNCH"

V63 (verb 63)

Set bit 6(N22ERNDS) of FLAGWRD9 = 0 (display N17 error)

Set bit 9(NEEDLFLG) of FLAGWRD0 = 1

Proceed to "PINBRNCH"

VB64 (verb 64)

Perform "TESTXACT"

Establish "SBANDANT" (priority 04_8)

End of job

CKOPTVB (verb 65)

If MODREG $\neq$ 02:

Proceed to "ALM/END"

Establish "GCOMPVER" (priority 16_8)

Proceed to "PINBRNCH"

ATTACHED (verb 66)

Establish "ATTACHIT" (priority 10_8)

End of job

ATTACHIT

Perform "INTSTALL"

Set bit 11(LMOONFLG) of FLAGWRD8 = 1

If bit 12(CMOONFLG) of FLAGWRD8 = 0:

Set bit 11(LMOONFLG) of FLAGWRD8 = 0

Inhibit interrupts

$\underline{R}_{rectlm} = \underline{R}_{rectcm}$

$\underline{V}_{rectlm} = \underline{V}_{rectcm}$

$T_{etlm} = T_{etcm}$

$DELTA\underline{V}_{lm} = DELTA\underline{V}_{cm}$

$NU\underline{V}_{lm} = NU\underline{V}_{cm}$

$RC\underline{V}_{lm} = RC\underline{V}_{cm}$

$VC\underline{V}_{lm} = VC\underline{V}_{cm}$

$T_{clm} = T_{ccm}$

$XKEP_{lm} = XKEP_{cm}$

Proceed to "TACHEXIT" (NOTE that Average-G cells $\underline{R}$ and $\underline{V}$ overwritten)

V67 (verb 67)

Perform "TESTXACT"

Establish "V67CALL" (priority 05_8)

End of job

V70UPDAT (verb 70)

See Uplink Processing

V71UPDAT (verb 71)

See Uplink Processing

V72UPDAT (verb 72)

See Uplink Processing

V73UPDAT (verb 73)

See Uplink Processing

DNEDUMP (verb 74)

DNTMGOTO = "DNDUMPI"

Proceed to "PINBRNCH"

LFTFLGON (verb 75)

Set bit 5(BKUPLO) of FLAGWRD5 = 1

Proceed to "PINBRNCH"

CHAZFOGC (verb 78)

If MODREG $\neq$ 02:

Proceed to "ALM/END"

Establish "AZMTHCG1" (priority 16_8)

Proceed to "PINBRNCH"

LEMVEC (verb 80)

Set bit 8(CSMUPDAT) of FLAGWRD1 = 0

Proceed to "PINBRNCH"

CSMVEC (verb 81)

Set bit 8(CSMUPDAT) of FLAGWRD1 = 1

Proceed to "PINBRNCH"

V82PERF (verb 82)

Perform "TESTXACT"

Change priority of present job to 07_8

Proceed to "V82CALL"

V83PERF (verb 83) Also established by "P79A"

Perform "TESTXACT"

Set bit 4(R31FLAG) of FLAGWRD9 = 1

Establish "R31CALL" (priority 05_8)

End of job

V85PERF (verb 85)

Perform "TESTXACT"

Set bit 4(R31FLAG) of FLAGWRD9 = 0

Establish "R31CALL" (priority 05_8)

End of job

V86PERF (verb 86)

If MRKBUF1 $\geqslant$ 0: (see notes with "MKREJECT")

MRKBUF1 = -1

Proceed to "PINBRNCH"

If bit 7(R22CAFLG) of FLAGWRD9 = 1:

Set bit 12(REJCTFLG) of FLGWRD10 = 1

Proceed to "PINBRNCH"

SETVHFLG (verb 87)

Set bit 9(VHFRFLAG) of FLAGWRD9 = 1

Proceed to "PINBRNCH"

RESETVHF (verb 88)

Inhibit interrupts

Set bit 8(Tracker) of DSPTAB+11 = 0, and flag for output at next opportunity

Set bit 7(OCDUFBIT) of OPTMODES = 1

Release interrupts

Set bit 9(VHFRFLAG) of FLAGWRD9 = 0

Proceed to "PINBRNCH"

V89PERF (verb 89)

If MODREG $\neq$ 0, proceed to "ALM/END"

Perform "TESTXACT"

Establish "V89CALL" (priority 10_8)

End of job

V90PERF (verb 90)

Perform "TESTXACT"

Establish "R36" (priority 07_8)

End of job

GOSHOSUM (verb 91)

If MODREG $\neq$ 0, proceed to "ALM/END"

Perform "TESTXACT"

Proceed to "SHOWSUM+2"

WMATRXNG (verb 93)

Set bit 1(RENDWFLG) of FLAGWRD5 = 0

Set bit 6(ORBWFLAG) of FLAGWRD3 = 0

Proceed to "PINBRNCH"

VERB94 (verb 94)

If bit 11(V94FLAG) of FLAGWRD9 = 0:

Proceed to "ALM/END"

Set bit 11(V94FLAG) of FLAGWRD9 = 0

If MODREG $\neq$ 23:

Proceed to "ALM/END"

Set restart group 2 to phase 11 (i.e. 2.11, to cause "V94ENTER" to be established with priority 14_8 by restart logic)

Inhibit interrupts

Proceed to "ENEMA"

VERB96 (verb 96)

Set bit 5(QUITFLAG) of FLAGWRD9 = 1

Set bit 3(V96ONFLG) of FLAGWRD8 = 1 (reset in "STATINT1")

TS = 0

Proceed to "V37"

Quantities in Computations

See also list of major variables and list of routines

A$\underline{K}$: See Digital Autopilot Interface Routines.

CADRSTOR: See Data Input/Output.

CPHI$\underline{X}$: See Digital Autopilot RCS Routines.

DELTA$\underline{V}_{cm}$, DELTA$\underline{V}_{lm}$: See Orbital Integration.

DESOPTS, DESOPTT: See Optics Computations.

DNTMGOTO: See Telemetry.

EXTVBACT: Single precision cell several of whose bits are used to control various performance features of the extended verbs. If the cell is non-zero, this means that the "extended verb display system" is busy, and other users are locked out (hence the cell can be set non-zero deliberately to lock out other users). The individual bits are used as follows:

Bit	Use
14	Set at start of "P61" and in "NEWRNVN" to inhibit extended verbs from using coding also used by P61 computations (e.g. R30 time-of-flight information).
12	Bit set 1 at end of "COMPDISP", used in "R31CALL" (for R31 and R34) to delay start of first display until completion of loading of data cells.
5	Bit set 1 by "TESTXACT", and used in "COMPDISP", "SBANDANT", "TICKTEST", and "V82GON1" to indicate, if 0, that a display response has been received (hence the cycling for updating of display should be stopped).
3	Set 1 in "TESTXACT" to indicate that display system extended verb portion is "busy" (not in general set for those extended verbs that do not require use of the display system "mark/extended verb" priority).
2	Set 1 in "TESTMARK" to indicate that optics marking system is in use.

IMODES30, IMODES33: See IMU Computations.

IMUCADR: See IMU Computations.

K_{shots}: Single precision constant, program notation "SHOLTS", scale factor B14, units centi-seconds. Value is 500 x 2^{-14}, corresponding to 5 seconds.

K_{st2cn}: Single precision constant, program notation "LST2CON", scale factor B14, value 40. VERBREG values of this amount or greater are considered "extended verbs".

K_{st2fn_i}: Table of single precision addresses, program notation "LST2FAN", giving (in the form of TC/TCF orders) starting addresses for processing of VERBREG values between K_{st2cn} and 99. See table below.

K_{vbt_i}: Table of single precision addresses, program notation "VERBTAB", giving (in the form of CADR addresses) the starting addresses for processing of VERBREG values less than K_{st2cn}. See table below.

LANDMARK: See Orbital and Rendezvous Navigation.

MONSAVE1: See Data Input/Output.

MPAC+0: See Display Interface Routines (loaded with verb that is received).

MRKBUF1: See Optics Computations.

NOUNREG: See Data Input/Output.

NOUT: See General Program Control.

NUM8NN: See Orbital and Rendezvous Navigation.

$NU\underline{V}_{cm}$, $NU\underline{V}_{lm}$: See Orbital Integration.

OGC: See Coordinate Transformations (scale factor could be considered B21 in units of gyro pulses as well as B0 revolutions): is loaded by N93.

OPTIND: See Optics Computations.

OPTIONX: See Display Computations.

OPTMODES: See Optics Computations.

PAC: See Coordinate Transformations (loaded by N92).

PBODY: See Orbital Integration.

$\underline{R}_{other}$: See Orbital Integration.

$\underline{R}_{rectcm}$, $\underline{R}_{rectlm}$: See Orbital Integration.

$RC\underline{V}$, $RC\underline{V}_{cm}$, $RC\underline{V}_{lm}$: See Orbital Integration.

SAC: See Coordinate Transformations (loaded by N92).

SWSAMPLE: See Optics Computations.

T_{ccm}, T_{clm}: See Orbital Integration.

T_{et}, T_{etcm}, T_{etlm}: See Orbital Integration.

TDELTA$\underline{V}$, TNU$\underline{V}$: See Orbital Integration.

$\underline{V}_{other}$: See Orbital Integration.

$\underline{V}_{rectcm}$, $\underline{V}_{rectlm}$: See Orbital Integration.

$VC\underline{V}$, $VC\underline{V}_{cm}$, $VC\underline{V}_{lm}$: See Orbital Integration.

VERBREG: See Data Input/Output.

$XKEP_{cm}$, $XKEP_{lm}$: See Orbital Integration.

Verb Table Information

Verb	Starts at	Function
00	"DSPALARM"	Not assigned.
01	"DSPA"	Display in octal first component.
02	"DSPB"	Display in octal second component.
03	"DSPC"	Display in octal third component.
04	"DSPAB"	Display in octal first and second components.
05	"DSPABC"	Display in octal all three components.
06	"DECDSP"	Decimal display.
07	"DSPDPDEC"	Double precision decimal display.
08-10	"DSPALARM"	Not assigned.
11-17	"MONITOR"	Perform monitor function of type specified by least significant digit of verb (e.g. verb 13 does "DSPC" periodically).
18-20	"DSPALARM"	Not assigned.
21	"ALOAD"	Load first component.
22	"BLOAD"	Load second component.
23	"CLOAD"	Load third component.
24	"ABLOAD"	Load first and second components.
25	"ABCLOAD"	Load all three components.
26	"DSPALARM"	Not assigned.
27	"DSPFMEM"	Display contents of fixed memory.
28-29	"DSPALARM"	Not assigned.
30	"VBRQEXEC"	Request executive system (for a job).
31	"VBRQWAIT"	Request waitlist system (for a task).
32	"VBRESEQ"	Recycle verb (same calling-routine return as a data enter).
33	"VBPROC"	Proceed (without data) verb.

Verb	Starts at	Function
34	"VBTERM"	Terminate (activity or function) verb.
35	"VBTSTLTS"	Test lights of display system.
36	"SLAP1"	Perform a (manually initiated) fresh start.
37	"MMCHANG"	Change program ("major mode").
38-39	"DSPALARM"	Not assigned.
40	"VBZERO"	Zero IMU CDU's.
41	"VBCOARK"	Coarse align (IMU CDU N20; optics CDU N91).
42	"IMUFINEK"	Fine align IMU (optional pulse torquing).
43	"IMUATTCK"	Load FDAI attitude error needles.
44	"SETSURF"	Set surface flag (LM state vector).
45	"RESTSRF"	Reset surface flag (LM state vector).
46	"STABLISH"	Establish G&C (DAP) control.
47	"LMTOCMSV"	Move LM state vector into CSM state vector.
48	"DAPDISP"	Load DAP data (R03).
49	"CREWMANU"	Start crew-defined maneuver (R62).
50	"GOLOADLV"	Please perform.
51	"GOLOADLV"	Please mark.
52	"V52"	Set offset mark number for P22.
53	"GOLOADLV"	Please mark alternate LOS.
54	"GOTOR23"	Start rendezvous backup sighting mark routine (R23).
55	"ALINTIME"	Increment computer clock (decimal input data).
56	"TRACKTRM"	Terminate tracking (P20).
57	"V57CALL"	Select FULTKFLG option (number of sensors).
58	"ENATMA"	Enable automatic attitude maneuvers in R61 and R67.
59	"GOLOADLV"	Please mark (optics calibration).

Verb	Starts at	Function
60	"V60"	Set CPHIX (N17) = CDU (N20).
61	"V61"	Display autopilot following error (RCS DAP "Mode I") on FDAI error needles.
62	"V62"	Display autopilot total attitude error with respect to N22 (RCS DAP "Mode II") on FDAI error needles.
63	"V63"	Display autopilot total attitude error with respect to N17 (RCS DAP "Mode III") on FDAI error needles.
64	"VB64"	Start S-band antenna angle calculation (R05).
65	"CKOPTVB"	Optical verification of prelaunch alignment (P03).
66	"ATTACHED"	Move CSM state vector into LM state vector.
67	"V67"	Start W-matrix RSS error display.
68	"ALM/END"	Not assigned.
69	(one-step loop)	Cause a hardware restart (one-step loop).
70	"V70UPDAT"	Liftoff time update (P27).
71	"V71UPDAT"	Block address update (P27).
72	"V72UPDAT"	Single address update (P27).
73	"V73UPDAT"	Increment computer clock (P27). Input is in units of centi-seconds, as contrasted with the hours, minutes, seconds input of V55.
74	"DNEDUMP"	Initialize downlink erasable memory dump.
75	"LFTFLGON"	Set liftoff flag (for backup liftoff).
76	"ALM/END"	Not assigned.
77	"ALM/END"	Not assigned.
78	"CHAZFOGC"	Change gyrocompass launch azimuth.
79	"ALM/END"	Not assigned.

Verb	Starts at	Function
80	"LEMVEC"	Cause LM state vector to be updated by navigation measurements (in P20).
81	"CSMVEC"	Cause CSM state vector to be updated by navigation measurements (in P20).
82	"V82PERF"	Request orbital parameter display (R30).
83	"V83PERF"	Request rendezvous parameter display #1 (R31, +X axis angle).
84	"ALM/END"	Not assigned (R32 is now P76).
85	"V85PERF"	Request rendezvous parameter display #2 (R34, optics angle).
86	"V86PERF"	Reject rendezvous backup sighting mark.
87	"SETVHFLG"	Set VHF range flag (for R22).
88	"RESETVHF"	Reset VHF range flag (for R22).
89	"V89PERF"	Start rendezvous final attitude routine (R63).
90	"V90PERF"	Request rendezvous out-of-plane display (R36).
91	"GOSHOSUM"	Compute banksums (of each fixed memory bank).
92	"ALM/END"	Not assigned.
93	"WMATRXNG"	Reset both W matrix flags (RENDWFLG and ORBWFLAG) to enable initialization.
94	"VERB94"	Enable cislunar tracking recycle (P23).
95	"ALM/END"	Not assigned.
96	"VERB96"	Terminate integration and go to P00.
97	"GOLOADLV"	Please perform engine-fail logic (R40).
98	"ALM/END"	Not assigned.
99	"GOLOADLV"	Please enable engine ignition.

Index of Routines

The routines listed below are those included by specific tag in this document. They are arranged in the "alphabetical" order of the listing of symbols at the end of the program: "+", "*", "-", A-Z, and 0-9.

Symbol	Document	Symbol	Document
LSPOS	COOR-7	NEXTINSL	TELE-4
LUNPOS	COOR-7	NODSPOUT	GENP-7
LUNVEL	COOR-8	NODSPY	GENP-6
L355	ENRY-16	NOGO	ATTM-10
M/SOUT	NNDF-4	NOPOLYM	BOOS-4
MAKEPLAY	DINT-7	NORMLIZE	GENP-1
MANUSTOP	ATTM-12	NORMRET	DINT-17
MARKDIF	OPTC-10	NOROLL	DPTV-14
MARKDISP	OPTC-23	NOROLL1	DPTV-15
MARKDONE	OPTC-11	NOUN	DATA-5
MARKMONR	DINT-5	NOUNTEST	DATA-19
MARKPLAY	DINT-12	NUM	DATA-3
MARKRUPT	OPTC-9	NVDSP	DINT-13
MASSPROP	DPIR-9	NVMONOPT	DATA-30
MIDTOAV1	ORBI-5	NVSUB	DATA-30
MIDTOAV2	ORBI-6	NVSUBEND	DATA-32
MINKDISP	MINK-1	NVSUBUSY	DINT-15
MKREJECT	OPTC-11	NV5ODSP	DINT-13
MKRELEAS	OPTC-8	NXTBNK	TEST-6
MKVBDSP	OPTC-8	N90/N81	BURN-23
MKVB5X	OPTC-9	OBLATE	ORBI-18
MKVB50	OPTC-9	OCCULT	INFA-7
MKVB51	OPTC-8	OCDUFTST	OPTC-6
MMCHANG	DATA-28	OHWELL1	UPLK-2
MONDO	DATA-23	OHWELL2	UPLK-2
MONITOR	DATA-22	OKTOCOPY	DINT-10
MONREQ	DATA-23	OKTOENT	DINT-17
MOONMX	COOR-12	ONCEMORE	TEST-12
MOVEACSM	ORBI-7	ONROLL	DPTV-12
MOVEALEM	ORBI-7	OPDEGOUT	NNDF-3
MOVEPCSM	ORBI-8	OPTDEGIN	NNDF-9
MOVEPLEM	ORBI-8	OPTMON	OPTC-3
MXM3	ATTM-9	OPTTEST	OPTC-1
NBDONLY	IMUC-2	ORIGCHNG	ORBI-14
NBD2	IMUC-2	PARAM	CONC-12
NBRANCH	ORBI-19	PASSOUT	ORVN-23
NDUTINPT	ORVN-3	PASTEVB	DATA-24
NEEDLER	DPIR-8	PCOPY	DPTV-8
NEEDLER2	DPIR-8	PERF20	MINK-9
NEEDLES	DPIR-8	PERIODCH	CONC-2
NEEDLE11	DPIR-8	PFAILOK	IMUC-9
NEGSGN	DATA-5	PHICALC-11	DISP-10
NEGTESTS	ENRY-11	PICEND	INFA-8
NEWANGL	ATTM-11	PIC1	INFA-6
NEWDELHI	ATTM-10	PIC3	INFA-6
NEWMODEX	DATA-33	PIKUP20	ORVN-4
NEWRNVN	ENTP-1	PINBRNCH	DINT-5
NEWSTATE	CONC-10	PIPACHK	TEST-13
NEXTCOL	ORBI-22	PIPASR	IMUC-1

Symbol	Document	Symbol	Document
PIPFREE	IMUC-14	P23	MEAS-18
PIPUSE	IMUC-14	P23.57	MEAS-22
PITCHDAP	DPTV-6	P23.60	MEAS-22
PITCHTIM	DPRC-19	P23.85	MEAS-22
PLANET	INFA-9	P23N7071	MEAS-19
PLAYJUM1	DINT-13	P29	ORVN-20
POINTAXS	MEAS-24	P30	BURN-1
POLYCOEF	CONC-16	P31	BURN-3
POODOO	GENP-26	P31RECYC	BURN-4
POSGN	DATA-5	P31RT	BURN-5
POSN17C	PREL-2	P32	BURN-5
POSTAND	GENP-23	P32/P72B	BURN-6
POSTBURN	BURN-32	P32/P72C	BURN-7
POSTTLI	BOOS-9	P33	BURN-9
POST41	BURN-32	P33/P73B	BURN-10
PRECOMP	DPTV-10	P34	BURN-14
PRECSET	REND-1	P34/P74C	BURN-15
PREC100	RTER-8	P35	BURN-20
PREC125	RTER-9	P35/P75B	BURN-21
PREC175	RTER-11	P36	BURN-21
PREC210	RTER-12	P36A	BURN-22
PREDICT3	ENRY-13	P36RECYC	BURN-23
PREFINAL	ENRY-12	P37	RTER-1
PREREAD	GENP-1	P37E	RTER-4
PREREAD1	GENP-1	P37W	RTER-18
PRERRORS	TEST-1	P40BLNKR	BURN-26
PRE40.6	DPIR-4	P40CSM	BURN-24
PRIODSP	DINT-5	P40RCS	BURN-32
PRIODSPR	DINT-5	P40S/F	BURN-24
PRIOLARM	GENP-25	P40S/SV	BURN-26
PROCEEDE	GENP-8	P40SXTY	BURN-24
PROCKEY	DATA-30	P41CSM	BURN-32
PROG20	ORVN-1	P47BODY	BURN-33
PROG21	ORVN-5	P47CSM	BURN-33
PROG22	ORVN-7	P51	INFA-1
PROG22A	ORVN-8	P51A	INFA-1
PROG24	ORVN-19	P51B	INFA-2
PROG52	INFA-3	P52AUTO	MINK-9
PUTCOM	DATA-20	P52B	INFA-3
PUTDCSF2	NNDF-7	P52C	INFA-6
PUTDECSF	DATA-21	P52D	INFA-5
PUTMARK	OPTC-11	P61	ENTP-1
P06	GENP-22	P62	ENTP-2
P11	BOOS-1	P62.1	ENTP-3
P15JOB	BOOS-6	P62.3	ENTP-4
P20OPT	ORVN-2	P63	ENTP-4
P20TRACK	ORVN-5	P65.1	ENRY-9
P21PROG1	ORVN-5	P67.1	ENRY-16
P21PROG2	ORVN-6	P67.2	ENRY-16
P22SUBRB	ORVN-9	P72	BURN-5

Symbol	Document
P73	BURN-9
P74	BURN-14
P75	BURN-20
P76ER77	BURN-33
P79	MINK-3
P79A	MINK-3
P791	MINK-3
P81	MINK-3
P82	MINK-3
P83	MINK-4
P84	MINK-4
P85	MINK-4
P86	MINK-5
QUICTRIG	COOR-3
QUIKREAD	GENP-3
R-TO-RP	COOR-11
RADSTART	MEAS-10
RANGER	ENRY-8
RANGERD1	MEAS-11
RATESUB	OPTC-19
RCSATT	DPRC-1
RCSDAPON	DPRC-1
RCYCLR61	ATTM-18
READACCS	GENP-2
READGYMB	DPEN-1
RECALTST	DATA-33
RECTEST	ORBI-15
RECTIFY	ORBI-13
RECTOUT	ORBI-11
REDAP	DPRC-4
REDOPRIO	DINT-12
REDORCS	DPRC-1
REDOR22	MEAS-17
REDOSAT	BOOS-5
REDOTVC	DPTV-10
REDO40.9	STER-7
REFLASH	DINT-6
REGODSP	DINT-6
REGODSPR	DINT-6
RELDSP	DATA-34
RELINUS	ATTM-3
RENDISP	MEAS-16
RENDISP2	MEAS-16
RENDISP3	MEAS-17
REND1	MEAS-9
REND12	MEAS-15
REND3	MEAS-9
REND30S	MINK-1
REND4	MEAS-11
REND5C	MEAS-12
REND7	MEAS-13
REPLACE	DPRC-23
REQDATX	DATA-11
REQDATY	DATA-11
REQDATZ	DATA-11
REQMM	DATA-28
RESETVHF	VBDF-14
REST	DINT-15
RESTSRF	VBDF-6
RETARG	PREL-9
REV37	GENP-21
ROLLDAP	DPTV-11
ROLLSET	DPTV-13
ROLLTIME	DPRC-17
ROO	GENP-19
ROPECHK	TEST-4
ROWDOT	MEAS-8
ROWDOT1	MEAS-8
RP-TO-R	COOR-11
RTEVN	RTER-6
RTE360	RTER-2
RO2BOTH	IMUC-1
R21END	OPTC-13
R22	MEAS-8
R23.10	MEAS-20
R23CSM	OPTC-13
R23CSM1	OPTC-13
R31CALL	DISP-11
R36	DISP-14
R51	INFA-11
R51DSPA	INFA-13
R51K	INFA-13
R52	OPTC-14
R52C	OPTC-14
R52D	OPTC-16
R52E	OPTC-19
R52FA	OPTC-16
R52H	OPTC-16
R53	OPTC-20
R53CHK	OPTC-18
R53C1	OPTC-21
R53JOB	OPTC-19
R54	INFA-13
R55	INFA-14
R55RET	INFA-14
R56	OPTC-22
R57	OPTC-23
R57C	OPTC-23

Symbol	Document
R57D	OPTC-24
R60CALL	MEAS-21
R60CSM	ATTM-2
R61CSM	ATTM-14
R61TEST	ATTM-3
R62DISP	ATTM-1
R63	ATTM-18
R63COM1	ATTM-19
R66CSM	ATTM-22
R67	ATTM-22
R67RSTRT	ATTM-23
R67START	ATTM-22
SATSTICK	BOOS-6
SATSTKON	BOOS-5
SBANDANT	DISP-2
SCALEPOP	ENRY-3
SCALPREP	GENP-23
SCNDSOL	REND-18
SELFCHK	TEST-1
SENDID	TELE-4
SEPMIN	NNDF-6
SEPSECNR	NNDF-5
SERVEXIT	GENP-2
SERVICER	GENP-4
SERVXT1	GENP-3
SETCOARS	IMUC-13
SETGWLST	PREL-4
SETINTG	MEAS-18
SETISSW	IMUC-8
SETJTAG	DPIR-1
SETMAXDB	DPIR-3
SETMINDB	DPIR-3
SETRE	COOR-10
SETSURF	VBDF-6
SETUP.9	STER-4
SETVHFLG	VBDF-14
SETWO+2	TELE-2
SFRUTMIX	DATA-19
SHOW	TEST-14
SHOWSUM+2	TEST-4
SICOM	MATH-1
SIVBCOMP	BOOS-7
SIVBOFF	BOOS-8
SLAP1	GENP-8
SLEEPIE	PREL-3
SLEEPIE	TEST-9
SMCDURES	COOR-4
SMODECHK	TEST-1
SNAPLOOP	TELE-3
SOMEERRR	TEST-13
SOMERR2	PREL-2
SOPTION	TEST-5
SPSICOM	MATH-2
SPSOFF	DPIR-4
SR30.1	DISP-7
STABLISH	DPIR-1
STARTAUT	MINK-2
STARTENT	ENRY-2
STARTEN1	ENRY-3
STARTSB2	GENP-13
STARTSUB	GENP-13
STATEINT	ORBI-1
STATINT1	ORBI-1
STICKCHK	DPIR-3
STKTEST	ATTM-17
STOPRATE	ATTM-13
STRTGYRO	IMUC-15
STRTGYR2	IMUC-15
SUFFCHEK	CONC-8
SVCT3	GENP-26
SWICHOVR	DPTV-3
SXTANG	COOR-6
SXTANG1	COOR-6
SXTMARK	OPTC-7
SXTNB	COOR-5
SXTSM	INFA-10
S22.1	ORVN-11
S22.981X	ORVN-18
S22BOX12	ORVN-16
S22BOX32	ORVN-15
S22GTP	ORVN-19
S22I=N	ORVN-17
S22NXTIN	ORVN-11
S22N7071	ORVN-9
S33/34.1	REND-1
S34/35.2	REND-5
S34/35.3	REND-6
S34/35.5	BURN-19
S3435.25	REND-6
S40.1	STER-1
S40.1B	STER-1
S40.13	STER-7
S40.14	DPIR-6
S40.15	DPIR-6
S40.2,3	STER-2
S40.2,3B	STER-3
S40.6	DPIR-4
S40.8	STER-5

Symbol	Document	Symbol	Document
S40.81	BURN-31	TWOPULSE	IMUC-18
S40.9	STER-6	T4RUPT	GENP-5
S41.1	STER-8	T5IDLOC	DPIR-1
S41.2	DPIR-6	T5PHASE2	DPRC-6
S50	INFA-8	T5RUPT	DPIR-1
S52.2	INFA-9	T6RESET	BOOS-7
S61.1	ENTP-4	T6RUPT	DPIR-1
S61.1A	ENTP-5	T6SET	BOOS-7
S61.1C	ENTP-5	T6SETUP	DPRC-21
S61.2	DISP-15	T6START	DPRC-22
TACHEXIT	VBDF-7	UNZ2	IMUC-9
TARGDRVE	PREL-9	UPCONTRL	ENRY-10
TARGETNG	ENRY-3	UPDATEOK	UPLK-1
TEMPSET	DPTV-6	UPDATEVG	STER-4
TERMSXT	OPTC-9	UPDATNN	DATA-11
TERM52	OPTC-19	UPDATVB	DATA-11
TESTLOOP	ORBI-12	UPDTCALL	ATTM-12
TESTMARK	OPTC-8	UPJOB	UPLK-3
TESTNN	DATA-9	UPOUT	UPLK-5
TESTXACT	VBDF-1	UPRUPT	DATA-1
TFFCONIC	DISP-17	UPSTORE	UPLK-3
TFFELL	DISP-19	UPVERIFY	UPLK-3
TICKTEST	DISP-6	USEPIOS	ORBI-11
TIG-0	BURN-27	UTAREA1	ATTM-19
TIG-5	BURN-27	UTOPT45	ATTM-20
TIGAVEG	BURN-26	VAC5STOR	TELE-5
TIGBLNK	BURN-26	VALMIS	TEST-13
TIGNOW	BURN-32	VARALARM	GENP-25
TIGON	BURN-33	VBCOARK	VBDF-3
TIMEDIDL	UPLK-5	VBPROC	DATA-29
TIMERAD	CONC-11	VBRELDSP	DATA-30
TIMESTEP	ORBI-14	VBRESEQ	DATA-29
TIMETHET	CONC-10	VBRQEXEC	DATA-29
TMRAD100	RTER-8	VBRQWAIT	DATA-29
TNONTEST	IMUC-5	VBTERM	DATA-30
TOBALL	ATTM-2	VBTSTLTS	VBDF-1
TORQUE	TEST-13	VBZERO	VBDF-3
TRACKTRM	VBDF-9	VB64	VBDF-11
TRANSPOS	ATTM-7	VECPOINT	ATTM-4
TRG*NBSM	COOR-4	VERB	DATA-4
TRMATTCK	VBDF-5	VERBFAN	VBDF-1
TSTFORDP	DATA-14	VERB94	VBDF-15
TSTLTS3	VBDF-2	VERB96	VBDF-15
TST2I=0	MEAS-7	VGCOMP	STER-4
TTG/0	BURN-33	VHFREAD	MEAS-10
TVCDAPON	DPTV-1	VHHDOT	BOOS-2
TVCEXEC	DPTV-4	VNFLASH	DINT-6
TVCINIT1	DPTV-1	VNFLASHR	DINT-6
TVCINIT4	DPTV-3	VN1645	BURN-18
TVCZAP	DPIR-4	VN1645R	BURN-19

Symbol	Document
V1N70DSP	ORVN-3
V2T100	RTER-12
V2T140	RTER-14
V2T145	RTER-14
V2T150	RTER-14
V2T175	RTER-15
V2T185	RTER-15
V37	GENP-15
V37XEQ	GENP-22
V52	VBDF-8
V57CALL	VBDF-9
V60	VBDF-10
V61	VBDF-10
V62	VBDF-10
V63	VBDF-11
V67	VBDF-12
V67CALL	MEAS-4
V70UPDAT	UPLK-1
V71UPDAT	UPLK-1
V72UPDAT	UPLK-1
V73UPDAT	UPLK-1
V82CALL	DISP-3
V82GOFF1	DISP-5
V82GOFLP	DISP-4
V82GON1	DISP-4
V82PERF	VBDF-13
V83CALL	DISP-11
V83PERF	VBDF-13
V85PERF	VBDF-13
V86PERF	VBDF-13
V89CALL	ATTM-1
V89PERF	VBDF-14
V89RECL	ATTM-1
V90PERF	VBDF-14
V94ENTER	MEAS-20
V97E	BURN-29
V97P	BURN-30
V97T	BURN-30
V99E	BURN-30
V99P	BURN-30
V99T	BURN-31
WAITONE	MEAS-17
WAKEP62	ENTP-4
WAKER	GENP-24
WDAGAIN	DATA-26
WLOOP	CONC-14
WMATRXNG	VBDF-14
XCHSLEEP	DINT-12
YAWDAP	DPTV-8

Symbol	Document
YAWTIME	DPRC-20
YCOPY	DPTV-9
ZEROJET	DPRC-5
1/CHECK	IMUC-3
1/GYRO	IMUC-3
1/PIPA	IMUC-1
1/WLOOP	CONC-15
1SHOTCHK	DPTV-5
11DSPIN	DATA-27
2BLANK	DATA-8
2INTOUT	NNDF-6
217ALARM	INFA-15
5BLANK	DATA-7
8192AUG	IMUC-17
9DWEPCAL	MEAS-6
9DWI=JA	MEAS-6
9DWTO6DW	MEAS-5

Minimum Key Rendezvous

AUTOCHK (Entered from "GOTOPOOH" and "NDUTINPT")

If bit 7(AUTOSEQ) of FLGWRD10 = 0:

Return

Set restart group 4 to cause a start at next line (priority 13_8) (tag here "AUTOCHK1"; from "PIKUP20")

Proceed to address specified by AUTPOINT

REND30S (Entered from "V37" if input program number in range 31-36 and [REFSMMAT] available)

TEMPMM = MMNUMBER + 50 (makes 31-36 into 81-86)

If bit 9(UTFLAG) of FLAGWRD8 = 1: (enter here from "V37" for P79)

Set bit 5(TRACKFLG) of FLAGWRD1 = 0

Set bit 9(UTFLAG) of FLAGWRD8 = 0

If bit 7(RNDVZFLG) of FLAGWRD0 = 0:

Set bit 7(AUTOSEQ) of FLGWRD10 = 1

TS = 20

Perform "AUTOSET" ("NDUTINPT", via "AUTOCHK", returns to next line)

MMNUMBER = TEMPMM (TEMPMM same cell as least significant half of $GDT1_z$)

Proceed to "AUTO37"

MINKDISP

AUTPOINT = Return address

TS = (MMNUMBER - 50) and perform "NEWMODEX"

Perform "RELDSP"

TS = 00017_8

Proceed to "GOPERF1": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to "STARTAUT"
otherwise, proceed

Set bit 7(AUTOSEQ) of FLGWRD10 = 0

Proceed to address specified by AUTPOINT

STARTAUT (Entered from "MINKDISP" and "P79")

If bit 8(AZIMFLAG) of FLGWRD11 = 0:

Set bit 8(AZIMFLAG) of FLGWRD11 = 1 (effect of "option 4")

If bit 11(HDSUPFLG) of FLGWRD10 = 1:

AZIMANGL = 0

If bit 11(HDSUPFLG) of FLGWRD10 = 0:

AZIMANGL = $\frac{1}{2}$ (i.e. 180°)

If bit 1(RENDWFLG) of FLAGWRD5 = 0:

Set bit 5(MANEUFLG) of FLGWRD10 = 1

Set bit 4(PTV93FLG) of FLGWRD10 = 1

Set bit 9(VHFRFLAG) of FLAGWRD9 = 1

Set bit 1(PCFLAG) of FLGWRD10 = 0

Set bit 7(AUTOSEQ) of FLGWRD10 = 1

Proceed to address specified by AUTPOINT

AUTOSET

AUTTEMP = Return address

MMNUMBER = TS

Set restart group 4 to cause a start at next line

AUTPOINT = AUTTEMP

Proceed to "AUTO37"

BURNHOW

AUTTEMP = Return address

If $|DELVLV\underline{C}| - K_{dv40d41} < 0$:

TS = 41

Proceed to second line of "AUTOSET"

TS = 40

Proceed to second line of "AUTOSET"

P79

Set bit 15(PCMANFLG) of FLGWRD10 = 1

Set bit 5(TRACKFLG) of FLAGWRD1 = 1

UTPIT = 0 (note UTYAW not set)

AUTPOINT = "P791"

Proceed to "STARTAUT" (exits to "P791")

P791

AUTPOINT = "P79A"

End of job ("PIKUP20", since PCMANFLG = 1, after doing R61 exits via "AUTOCHK" to "P79A": note [REFSMMAT] must be available)

P79A

Establish "V83PERF" (priority 05_8)

Proceed to "P20TRACK"

P81

Perform "MINKDISP"

TS = 31

Perform "AUTOSET"

Perform "BURNHOW"

Perform "AFTERBRN"

Proceed to second line of "P82"

P82

Perform "MINKDISP"

Set bit 6(CSISFLAG) of FLGWRD11 = 0 (Tag here "P82CONT1")

TS = 32

Perform "AUTOSET"

Perform "BURNHOW"

Perform "AFTERBRN"

$R_{targ_{x_{sp}}}$ = NN1 - 2 (temporary storage for restart protection)

Set restart group 4 to cause a start at next line

$NN1 = R_{targ_{x_{sp}}}$

If(NN1 - 2) $<$ 0: (i.e. in P32 was $\leq$ 3)

Proceed to second line of "P86"

Set bit 6(CSISFLAG) of FLGWRD11 = 1

$T_{csi} = T_{csi2}$ (T_{csi2} loaded in "CIRCL")

If (NN1 - 2) $\leq$ 0: (i.e. equals 2, since if less already exit; means was 4 in P32)

Proceed to second line of "P81"

Proceed to second line of "P82" (as noted by J. Monroe, CG22, should be to third line instead)

P83

Perform "MINKDISP"

TS = 33

Perform "AUTOSET"

Perform "BURNHOW"

Set bit 5(LMACTFLG) of FLAGWRD2 = 1 (Causes LM state vector in normal CSM slots for targeting)

Perform "AFTERBRN"

Proceed to second line of "P84"

P84

Perform "MINKDISP"

TS = 34

Perform "AUTOSET"

Perform "BURNHOW"

Perform "AFTERBRN"

Proceed to second line of "P85"

P85

Perform "MINKDISP"

TS = 35

Perform "AUTOSET"

Perform "BURNHOW"

Perform "AFTERBRN"

TS = 35

Perform "AUTOSET"

Perform "BURNHOW"

Perform "AFTERBRN"

MMNUMBER = 79

Proceed to "AUTO37"

P86

Perform "MINKDISP"

TS = 36

Perform "AUTOSET"

If $|\underline{\text{DELVLVC}}| = 0$: (all components below 2^{-14} m/cs $\cong$ 0.02 fps)

Set bit 10(BURNFLAG) of FLGWRD10 = 1 (forces DELVO$\underline{\text{V}}$ to be set 0)

Perform "AFTERBRN"

Proceed to second line of "P83"

TS = 52

Perform "AUTOSET"

If bit 1(PCFLAG) of FLGWRD10 = 1: (set by "P36"; reset in "GYCRS" if do pulse torquing)

TS = 41

Perform "AUTOSET"

Perform "AFTERBRN"

Proceed to second line of "P83"

Perform "BURNHOW"

Perform "AFTERBRN"

Set bit 15(PCMANFLG) of FLGWRD10 = 1 (Tag here "P86CONT2")

TS = 20

Perform "AUTOSET" ("PIKUP20", since PCMANFLG = 1, after R61 exits)

Set bit 15(PCMANFLG) of FLGWRD10 = 0

TS = 52

Perform "AUTOSET"

Proceed to second line of "P83"

<u>AFTERBRN</u>

AUTTEMP = Return address

Establish "HARTBURN" (priority 07_8)

End of job

<u>HARTBURN</u>

If bit 10(BURNFLAG) of FLGWRD10 = 1:

DELVOV = 0

TS = 76

Proceed to second line of "AUTOSET"

If bit 3(TPIMNFLG) of FLGWRD10 = 1: (set 1 by "S34/35.5")

(NOTE that once TPIMNFLG = 1, will come here regardless of what targeting was actually done; bit reset by "P74")

BURNTMP2 = $\underline{R}_{pass3}$

BURNTMP1 = $\underline{R}_{act3}$

BURNTMP3 = $\underline{V}_{act3}$

BURNTMP4 = $\underline{V}_{pass3}$

Set restart group 4 to cause a start at next line

$\underline{V}_{pass3}$ = BURNTMP3

$\underline{R}_{act3}$ = BURNTMP2

$\underline{R}_{pass3}$ = BURNTMP1

$\underline{V}_{act3}$ = BURNTMP4

ULOS = unit($\underline{R}_{pass3} - \underline{R}_{act3}$)

UNRM = unit($\underline{R}_{act3} * \underline{V}_{act3}$)

(If bit 3(TPIMNFLG) of FLGWRD10 = 1):

Perform "S34/35.2"

$DELVO\underline{V} = DELVLV\underline{C}$

TS = 76

Proceed to second line of "AUTOSET"

If bit 5(LMACTFLG) of FLAGWRD2 = 1: (Tag here "NOTTPI"; bit set by "P83")

TS = NOMTIG

Perform "ADVANCE"

Perform "CDHMVR"

$T\underline{S}_2 = - UP\underline{1}$

$T\underline{S}_3 = -unit\underline{R}_{actl}$

$T\underline{S}_1 = T\underline{S}_3 * UP\underline{1}$

$$DELVO\underline{V} = \begin{bmatrix} T\underline{S}_1 \\ T\underline{S}_2 \\ T\underline{S}_3 \end{bmatrix} DELVEET\underline{2}$$

$DELVOV_y = CMYDOT$ (CMYDOT is "active" vehicle, i.e. LM)

TS = 76

Proceed to second line of "AUTOSET"

$DELVO\underline{V} = - DELVLV\underline{C}$ (Tag here "NOTCDH")

$DELVOV_y = LMYDOT$

TS = 76

Proceed to second line of "AUTOSET"

<u>AUTOW</u> (Entered from "REND4" if bit 7(AUTOSEQ) of FLGWRD10 = 1)

If bit 5(MANEUFLG) of FLGWRD10 = 1:

If bit 4(PTV93FLG) of FLGWRD10 = 1: (Tag here "AUTOW3")

Proceed to "REND5C" (initialize W matrix)

(If bit 5(MANEUFLG) of FLGWRD10 = 1):

If bit 3(TPIMNFLG) of FLGWRD10 = 1:

If bit 2(FULTKFLG) of FLGWRD10 = 0: (means have both VHF & optics)

Proceed to "REND5C" (initialize W matrix)

COUNT3MK = 1 (Tag here "AUTOW4")

Proceed to "AUTOW2"

If COUNT3MK $\neq$ 0:

Proceed to "AUTOW2"

If bit 3(TPIMNFLG) of FLGWRD10 = 1: (Tag here "AUTOW1A")

If bit 8(P35FLAG) of FLGWRD10 = 1: (NOTE that once TPIMNFLG = 1, come here regardless of what program is actually in use)

Proceed to "REND5C" (initialize W matrix)

Proceed to "AUTOW2"

TS = T_{ig} (Tag here "AUTOW1")

If bit 1(PCFLAG) of FLGWRD10 = 1:

TS = T_{cdh}

If (MARKTIME $-$ $C_{wrdtime}$ $-$ AGEOFW) $<$ 0: (i.e. W matrix not old enough)

Proceed to "AUTOW2"

If (OLDMKTME $-$ MARKTIME $+$ $C_{minblktm}$) $<$ 0: (i.e. too long since last processed mark)

COUNT3MK = 1

Proceed to "AUTOW2"

TS_1 = MARKTIME $-$ TS

If $TS_1 \not> 0$: (NOTE that this means if delay in answering initial P3x display, may force an initialization)

Set bit 4(PTV93FLG) of FLGWRD10 = 0

Proceed to "REND5C" (initialize W matrix)

If (TS_1 $+$ $C_{fincmptm}$ $+$ $C_{tbefcomp}$) $<$ 0: (i.e. enough time before maneuver available)

Set bit 4(PTV93FLG) of FLGWRD10 = 0

Proceed to "REND5C" (initialize W matrix)

If $(TS + K_{3mincon} - C_{fincmptm} + C_{brnblktm} - AGEOFW - C_{maxwtime}) \geq 0$:

Set bit 4(PTV93FLG) of FLGWRD10 = 1

Proceed to "AUTOW2"

AUTOW2

Set bit 6(ORBWFLAG) of FLAGWRD3 = 0

If bit 1(RENDWFLG) of FLAGWRD5 = 0:

Proceed to "REND5C" (initialize W matrix)

Set bit 1(RENDWFLG) of FLAGWRD5 = 1 (unnecessary)

Proceed to "REND7"

P52AUTO (Entered from "PROG52" if bit 7(AUTOSEQ) of FLGWRD10 = 1)

$T\underline{S} = \frac{1}{2}\ REFSMMA\underline{T}_3$ (note that no check for direction of burn is made)

If bit 1(PCFLAG) of FLGWRD10 = 0: (after burn)

$T\underline{S} = -\ T\underline{S}$

$\underline{X}_{smd} = \text{unit}(\frac{1}{2}\ REFSMMA\underline{T}_0 + T\underline{S})$

$\underline{Z}_{smd} = REFSMMA\underline{T}_6$

$\underline{Y}_{smd} = \text{unit}(\underline{Z}_{smd} * \underline{X}_{smd})$

Set bit 4(PFRATFLG) of FLAGWRD2 = 1

Proceed to "P52D"

PERF20 (Entered from "P52D" if bit 7(AUTOSEQ) of FLGWRD10 = 1)

$TS = 20_8$

Proceed to "GOPERF1": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to "GYCRS"
otherwise, proceed

If bit 1(PCFLAG) of FLGWRD10 = 1: (i.e. before burn, not yet torqued)

Proceed to second line of "GOTOPOOH"

Perform "ALARM" (pattern 0402_8)

Proceed to "PERF20"

Quantities in Computations

See also list of major variables and list of routines

AGEOFW: See Measurement Incorporation.

AUTPOINT: Single precision cell used for return address storage in the minimum key rendezvous logic. It could be considered as a "pointer" indicating the progress of the computations through the P8x "driver".

AUTTEMP: Single precision cell used as temporary storage for information to be placed in AUTPOINT (to simplify some program logic and for the sake of restart protection).

AZIMANGL: See Orbital and Rendezvous Navigation.

BURNTMP1, BURNTMP2, BURNTMP3, BURNTMP4: Cells used for temporary storage of active and passive vehicle vectors in "HARTBURN" (to allow them to be exchanged without causing difficulty in the event of a restart).

$C_{brnblktm}$: Single precision erasable memory constant, program notation "BRNBLKTM", scale factor B28, units centi-seconds. Least increment is 163.84 seconds. Used in the determination of age of W matrix following next maneuver (typical value when in fixed memory was 5 least increments), for $C_{maxwtime}$ check. Five increments about 13.653'.

$C_{fincmptm}$: Single precision erasable memory constant, program notation "FINCMPTM", scale factor B28, units centi-seconds. Least increment is 163.84 seconds. Used to allow for length of time of final targeting computation (typical value when in fixed memory was 3 least increments), e.g. for $C_{tbefcomp}$ check. Three increments about 8.192'.

$C_{maxwtime}$: Single precision erasable memory constant, program notation "MAXWTIME", scale factor B28, units centi-seconds. Least increment is 163.84 seconds. Used to determine if W matrix age will be excessive after next maneuver (typical value when in fixed memory was 22 least increments, or about 60.075 minutes).

$C_{minblktm}$: Single precision erasable memory constant, program notation "MINBLKTM", scale factor B28, units centi-seconds. Least increment is 163.84 seconds. Used to check whether time since last mark excessive (if so, COUNT3MK is set 1). Typical value when in fixed memory was 2 least increments, or about 5.461 minutes.

$C_{tbefcomp}$: Single precision erasable memory constant, program notation "TBEFCOMP", scale factor B28, units centi-seconds. Least increment is 163.84 seconds. Used to check if a sufficient time remains before the final targeting computation so that W matrix reinitialization should take place. Typical value when in fixed memory was 5 least increments, or about 13.653 minutes.

$C_{wrdtime}$: Single precision erasable memory constant, program notation "WRDTIME", scale factor B28, units centi-seconds. Least increment is 163.84 seconds. Used to check if sufficient time has elapsed since the previous W matrix initialization. Typical value when in fixed memory was 9 least increments, or about 24.576 minutes(recently $\sim$41 min).

CMYDOT: See Burn Control.

COUNT3MK: Single precision counter, scale factor B14, units counts, used to control the initialization of the W matrix after three marks accumulated (hence the name). It is incremented in "REND12", where it is also set zero after reaching 3. If non-zero, checks in "AUTOW", except immediately following a burn, are bypassed.

DELVEET$\underline{2}$: See Rendezvous Computations.

DELVLV$\underline{C}$: See Burn Control.

DELVO$\underline{V}$: See Burn Control.

$K_{3mincon}$: Single precision constant, program notation "3MINCON", scale factor B28, units centi-seconds. Used double precision with octal value 00001_8 00002_8, corresponding to 163.86 seconds or 2.731 minutes.

$K_{dv40d41}$: Constant, program notation "DV40/41", scale factor B7, units meters/centi-second. Value is 0.021336×2^{-7}, corresponding to $7 \times 0.3048 \times 0.01 \times 2^{-7}$, where first term is value in fps, second converts to meters, third to centi-seconds, and fourth is scale factor.

LMYDOT: See Burn Control.

MARKTIME: See Measurement Incorporation.

MMNUMBER: See General Program Control.

NN1: See Rendezvous Computations.

NOMTIG: See Burn Control.

OLDMKTME: See Measurement Incorporation.

$\underline{R}_{act1}$, $\underline{R}_{act3}$, $\underline{R}_{pass3}$: See Rendezvous Computations.

$\underline{R}_{targ}$: See Rendezvous Computations. Used in "P82" as temporary storage for restart protection purposes (scaling, of course, is B14 for $R_{targ_{x_{sp}}}$ there).

T_{cdh}, T_{csi}, T_{csi2}: See Rendezvous Computations.

TEMPMM: Temporary storage for program number to be used in searching the program tables in V37 logic (in range 81-86, or 79 if that program selected), scale factor B14, single precision. Used in "REND30S" to allow start-up of P20 and then initiation of desired program.

ULO$\underline{S}$: See Rendezvous Computations.

UNR$\underline{M}$: See Rendezvous Computations.

UP$\underline{1}$: See Rendezvous Computations.

UTPIT: See Orbital and Rendezvous Navigation.

$\underline{V}_{act3}$, $\underline{V}_{pass3}$: See Rendezvous Computations.

$\underline{X}_{smd}$, $\underline{Y}_{smd}$, $\underline{Z}_{smd}$: See Inflight Alignment.

Noun Definitions

DPTEST

If TS_1 = 4, 5, 7, 10, or 13, indicate double precision (return to calling address +2)

If TS_1 = 0, 1, 2, 3, 6, 8, 9, 11, or 12, indicate single precision (return to calling address +1)

GTSFOUT

SFTEMP1 = $K_{sfot_{TS}}$

Return

GTSFIN

SFTEMP1 = $K_{sfin_{TS}}$

Return

LODNNTAB

NNADTEM = $K_{ntb_{NOUNREG}}$

NNTYPTEM = $K_{nty_{NOUNREG}}$

If NOUNREG $<$ K_{mxcn}:

MIXBR = 1

Return

MIXBR = 2

TS = NOUNREG - 40

RUTMXTEM = $K_{rtmtb_{TS}}$

TS = bits 10-1 of NNADTEM

IDAD1TEM = $K_{idtb_{TS}}$

IDAD2TEM = $K_{idtb_{TS+1}}$

IDAD3TEM = $K_{idtb_{TS+2}}$

Return

NOTE: IDAD<u>I</u>TEM$_i$ refers to:

IDAD1TEM if i = 1
IDAD2TEM if i = 2
IDAD3TEM if i = 3

DECDSP3

Proceed to address given by the following table:

TS_1	Address
0	"DSPALARM" (after setting DSPCOUNT = -19)
1	"DSPDCEND"
2	"DEGOUTSF"
3	"ARTOUTSF"
4	"DP1OUTSF"
5	"DP2OUTSF"
6	"OPDEGOUT"
7	"DP3OUTSF"
8	"HMSOUT"
9	"M/SOUT"
10	"DP2OUTSF"
11	"AROUT1SF"
12	"2INTOUT"
13	"DPFRACOT"

DEGOUTSF

If MPAC+0 $\leqslant$ -0:

Set bit 15 of MPAC+0 = 0

SFTEMP1 = K_{dgtb_0}

$MPAC_{dp} = K_{dgtb_0}$ MPAC+0 + SFTEMP1

Proceed to "DSPDCEND"

ARTOUTSF (no shift)

If MPAC+0 = -0:

$MPAC_{dp}$ = -0

Proceed to "DSPDCEND"

$MPAC_{dp}$ = SFTEMP1 MPAC+0

Proceed to "DSPDCEND"

DP1OUTSF (left shift of 14)

Perform "DPOUT"

$MPAC_{dp} = 2^{14}\ MPAC_{tp}$ (left shift of 14, overflow information lost)

Proceed to "DSPDCEND"

DP2OUTSF (no shift)

Perform "DPOUT"

Proceed to "DSPDCEND"

OPDEGOUT

$TS = MPAC+0$

If $TS \geq +0$:

$MPAC+0 = MPAC+0 + K_{20b}$ (overflows propagate to bit 15)

If $TS \leq -0$:

$MPAC+0 = MPAC+0 + K_{20b}$

If $MPAC+0 > 0$: (includes case where $TS = -0$)

$MPAC+0 = MPAC+0 + K_{ngl}$

If $MPAC+0 \leq -0$:

Set bit 15 of $MPAC+0 = 0$

$SFTEMP1 = K_{dgtb_2}$

$MPAC_{dp} = K_{dgtb_2} \ MPAC+0 + SFTEMP1$

Proceed to "DSPDCEND"

DP3OUTSF (left shift of 7)

Perform "DPOUT"

$MPAC_{tp} = 2^7 \ MPAC_{tp}$ (left shift 7, OVFINP set if overflow)

Proceed to "DSPDCEND"

HMSOUT

If $MIXBR = 1$:

$TS = NOUNADD$

If $MIXBR = 2$:

$EBANK =$ bits 11-9 of $IDAD\underline{I}TEM_{DECOUNT+1}$ (i.e. IDAD2TEM for DECOUNT = 1)

$TS = 1400_8 +$ bits 8-1 of $IDAD\underline{I}TEM_{DECOUNT+1}$

$MPAC_{dp} = E_{TS_{dp}}$, with sign agreement forced

Perform "SEPSECNR"

$MPAC_{dp} = K_{scn2}\ MPAC_{dp}$

DSPCOUNT = 4

Perform "DSPDECWD" (display seconds in R3)

Perform "SEPMIN"

$TS_2 =$ MPAC+0 (whole hours)

If MPAC+1 = -0:

  $MPAC_{dp} = -0$

If MPAC+1 $\neq$ -0:

  $MPAC_{dp} = K_{mncn2}$ MPAC+1

DSPCOUNT = 9

Perform "DSPDECWD" (display minutes in R2)

If $TS_2 = -0$:

  $MPAC_{dp} = -0$

If $TS_2 \neq -0$:

  $MPAC_{dp} = K_{hrcn1}\ TS_2$

DSPCOUNT = 14

Perform "DSPDECWD" (display hours in R1)

Proceed to address specified by ENTRET

<u>M/SOUT</u>

If MIXBR = 1:

  TS = NOUNADD

If MIXBR = 2:

  EBANK = bits 11-9 of $IDAD\underline{I}TEM_{DECOUNT+1}$ (i.e. IDAD2TEM for DECOUNT = 1)

  $TS = 1400_8$ + bits 8-1 of $IDAD\underline{I}TEM_{DECOUNT+1}$

$MPAC_{dp} = E_{TS_{dp}}$, with sign agreement forced

$TS = MPAC_{dp}$

If $|TS| \geq K_{mscn12}$:

$MPAC_{dp} = K_{mscn3}$ sgn MPAC+0

Perform "SEPSECNR"

If $|TS| < K_{mscn12}$:

$MPAC_{dp} = MPAC_{dp} + K_{rndcn}$ sgn MPAC+1

Perform "SEPSECNR"

$MPAC_{dp} = K_{hisec} MPAC_{dp}$

DSPCOUNT = DSPCOUNT - 3

Perform "DSPDC2NR" (seconds in digits 4 and 5)

CODE = 0

$COUNT = K_{rd_{DECOUNT}} - 2$

Perform "DSPIN" (blank digit 3)

Perform "SEPMIN"

$MPAC_{dp} = K_{himin}$ MPAC+1

$DSPCOUNT = K_{rd_{DECOUNT}}$

Perform "DSPDC2NR" (minutes in digits 1 and 2)

Proceed to second line of "DSPDCEND"

<u>SEPSECNR</u>

$MPAC_{tp} = K_{scn1} MPAC_{dp}$

$HITEMOUT = MPAC_{dp}$

$MPAC_{tp} = 2^2 MPAC_{tp}$ (left shift 2, OVFINP set if overflow)

$MPAC_{dp} = 2^{14} MPAC_{tp}$ (left shift 14, overflow information lost, leaves seconds in $MPAC_{dp}$)

Return

SEPMIN

$MPAC_{dp}$ = HITEMOUT

Set bits 12-1 of MPAC+1 = sign bit (i.e. zero magnitude, masking out former information on seconds)

$MPAC_{tp} = K_{mncnl}\ MPAC_{dp}$

Return

AROUT1SF (left shift of 14, single precision operand)

If MPAC+0 = -0:

$MPAC_{dp}$ = -0

Proceed to "DSPDCEND"

$MPAC_{tp}$ = SFTEMP1 MPAC+0

$MPAC_{dp} = 2^{14}\ MPAC_{tp}$ (left shift of 14, overflow information lost)

Proceed to "DSPDCEND"

2INTOUT

Perform "5BLANK" (blanks all digits)

Perform "+ON"

TS = MPAC+0

Perform "DSPDECVN" (puts first cell in digits 1 and 2)

$DSPCOUNT = K_{rd_{DECOUNT}} - 3$

If MIXBR = 1:

TS = NOUNADD

If MIXBR = 2:

EBANK = bits 11-9 of $IDAD\underline{I}TEM_{DECOUNT+1}$

$TS = 1400_8$ + bits 8-1 of $IDAD\underline{I}TEM_{DECOUNT+1}$

$MPAC_{dp} = E_{TS_{dp}}$

TS = MPAC+1

Perform "DSPDECVN" (puts second cell in digits 4 and 5)

Proceed to second line of "DSPDCEND"

DPFRACOT

If MIXBR = 1:

TS = NOUNADD

If MIXBR = 2:

EBANK = bits 11-9 of $IDADITEM_{DECOUNT+1}$

TS = 1400_8 + bits 8-1 of $IDADITEM_{DECOUNT+1}$

$MPAC_{dp} = E_{TS_{dp}}$

Proceed to "DSPDCEND"

PUTDCSF2

Proceed to address given by the following table:

TS_1	Address
0	"ALMCYCLE" (noun octal only)
1	"BINROUND"
2	"DEGINSF"
3	"ARTHINSF"
4	"DPINSF"
5	"DPINSF2"
6	"OPTDEGIN"
7	"DPINSF"
8	"HMSIN"
9	"DSPALARM" (can't load MMBSS)
10	"DPINSF4"
11	"ARTIN1SF"
12	"DSPALARM" (can't load XXBYY)
13	"DPFRACIN"

DEGINSF

$MPAC_{tp} = K_{dgcnl}\ MPAC_{dp}$

$MPAC_{tp} = MPAC_{tp} + K_{btll}$ sgn MPAC+1 If overflow, set OVFINP

$MPAC_{tp} = 2^1\ MPAC_{tp}$ (left shift 1) If overflow, set OVFINP

Proceed to "DEGINSF2"

DEGINSF2

$MPAC_{tp} = 2^1\ MPAC_{tp}$ (left shift 1) If overflow, set OVFINP

If OVFINP set (i.e. non-zero), proceed to "ALMCYCLE"

$MPAC_{tp} = 2^1\ MPAC_{tp}$ (left shift 1)

If overflow takes place:

OVFINP = 1 sgn MPAC+0

If MPAC+0 = -0:

MPAC+0 = +0

If MPAC+0 $<$ 0:

MPAC+0 = MPAC+0 + 00001_8 (for twos complement)

If OVFINP = 0:

TS = MPAC+0

Proceed to address specified by DECRET

If OVFINP $>$ 0:

Set bit 15 of MPAC+0 = 1

TS = MPAC+0

Proceed to address specified by DECRET

If MPAC+0 = +0: (OVFINP is $<$0 if come here)

MPAC+0 = 40000_8

TS = MPAC+0

Proceed to address specified by DECRET

Set bit 15 of MPAC+0 = 0

TS = MPAC+0

Proceed to address specified by DECRET

ARTHINSF (left shift of 14)

$MPAC_{tp}$ = SFTEMP1 $MPAC_{dp}$

If MPAC+0 $\neq$ 0, procced to "ALMCYCLE"

$MPAC_{dp} = 2^{14}$ $MPAC_{tp}$ (left shift of 14)

Proceed to "BINROUND"

DPINSF2 (left shift of 7)

$MPAC_{tp}$ = SFTEMP1 $MPAC_{dp}$

$MPAC_{tp} = 2^7$ $MPAC_{tp}$ (left shift of 7, OVFINP set if overflow)

Proceed to second line of "DPINSF"

OPTDEGIN

If MPAC+0 $\leq$ -0, proceed to "ALMCYCLE"

$MPAC+0 = MPAC+0 + K_{ngp2}$

$MPAC_{tp} = K_{dgcn2}\ MPAC_{dp}$

$MPAC_{tp} = MPAC_{tp} + K_{btl2}$ If overflow, set OVFINP

Proceed to "DEGINSF2"

HMSIN

If bits 5-3 of DECBRNCH $\neq 111_2$: (3 decimal inputs not received)

VERBSAVE = -25 (force verb 25)

Proceed to "ALMCYCLE"

$MPAC_{tp} = K_{whecn}\ MPAC_{dp}$ ($MPAC_{dp}$ contains hours)

$MPAC_{tp} = MPAC_{tp} + MPAC+2$

If MPAC+0 $\neq$ 0, proceed to "ALMCYCLE"

$MPAC_{tp} = K_{hrcon}\ MPAC+1$

If MPAC+0 $\neq$ 0, proceed to "ALMCYCLE" (input exceeded 745 hours)

$TS = 2^{14}\ MPAC_{tp}$ (left shift 14)

$MPAC_{dp}$ = (YREG, YREGLP) ($MPAC_{dp}$ loaded with minutes)

$MPAC_{tp} = K_{whecon}\ MPAC_{dp}$

$MPAC_{tp} = MPAC_{tp} + MPAC+2$

If MPAC+0 $\neq$ 0, proceed to "ALMCYCLE"

If $|MPAC+1| > K_{59min}$, proceed to "ALMCYCLE"

$TS = TS + K_{mincon}\ MPAC+1$

If $|TS| \geqslant 2^{28}$ centi-seconds, proceed to "ALMCYCLE"

$MPAC_{dp}$ = (ZREG, ZREGLP) ($MPAC_{dp}$ loaded with centi-seconds)

$MPAC_{tp} = K_{whecon}\ MPAC_{dp}$

$MPAC_{tp} = MPAC_{tp} + MPAC+2$

If MPAC+0 $\neq$ 0, proceed to "ALMCYCLE"

If $|MPAC+1| > K_{5999sc}$, proceed to "ALMCYCLE"

$TS = TS + MPAC_{dp}$

If $|TS| \geq 2^{28}$ centi-seconds, proceed to "ALMCYCLE"

Force sign agreement of TS (maximum time is $2^{28} - 1$ centi-seconds, i.e. 745 h, 39 m, 14.55 sec; or 31 d, 1 hr, 39 m, 14.55 s)

$E_{NOUNADD} = TS_{dp}$

Proceed to "LOADLV"

DPINSF4 (left shift 3)

$MPAC_{tp} = SFTEMP1\ MPAC_{dp}$

$MPAC_{dp} = 2^3\ MPAC_{tp}$ (left shift of 3, OVFINP set if overflow)

Proceed to second line of "DPINSF"

ARTIN1SF (no shift)

$MPAC_{tp} = SFTEMP1\ MPAC_{dp}$

Proceed to "BINROUND"

DPFRACIN

Proceed to 4th line of "DPINSF"

Quantities in Computations

See also list of major variables and list of routines

CODE, COUNT: See Data Input/Output.

DECBRNCH, DECOUNT, DECRET: See Data Input/Output.

DSPCOUNT: See Data Input/Output.

EBANK, ENTRET: See Data Input/Output.

HITEMOUT: Value of number of minutes in time quantity (computed in "SEPSECNR" for use in "SEPMIN"), scale factor B16, units minutes. Least significant 12 bits of least significant half contain fractional portion of minutes, and therefore must be blanked in "SEPMIN" for proper computation of the number of integral minutes in the time argument. Least significant half "LOTEMOUT".

IDAD$\underline{I}$TEM ($\underline{I}$ = 1,2,3): Temporary storage for information from mixed-noun tables (see below) for first (R1), second (R2), and third (R3) components of noun. The R1 component, of course, is displayed in register R1 on the DSKY, etc.

K_{20b}: Single precision constant, program notation "20BIAS", scale factor B-3, units revolutions. Octal value is 16040_8, corresponding to about 19.7754°.

K_{59min}: Single precision constant, program notation "59MIN", scale factor B14, units minutes. Value is 00073_8, corresponding to 59 minutes.

K_{5999sc}: Single precision constant, program notation "59.99SEC", scale factor B14, units centi-seconds. Value is 13557_8, corresponding to 5999 centi-seconds (or 59.99 seconds).

K_{bt11}: Single precision constant, program notation "BIT11". As used, value corresponds to ($\frac{1}{2} \times 2^{-14}$) of full scale, or one-half the least increment on the single precision result for "DEGINSF".

K_{bt12}: Single precision constant, program notation "BIT12". As used, value corresponds to ($\frac{1}{2} \times 2^{-14}$) of full scale, or one-half the least increment on the single precision result for "OPTDEGIN".

K_{dgcn1}: Constant, program notation "DEGCON1", scale factor B3, value $5.555555555 \times 2^{-3}$. Value corresponds to $(1000/180) \times 2^{-3}$, where first term converts from XXX.XX° to B-1 revolutions, and second is the constant's scale factor.

K_{dgcn2}: Constant, program notation "DEGCON2", scale factor B2, value $2.222222222 \times 2^{-2}$. Value corresponds to $(100/45) \times 2^{-2}$, where first term converts from XX.XXX° to B-3 revolutions, and second is the constant's scale factor.

K_{dgtb0}: Constant, program notation "DEGTAB", scale factor B0, octal value 05605_8 03656_8, corresponding to decimal 0.18. Value equivalent to 180/1000, to convert from B-1 revolutions to XXX.XX°.

K_{dgtb_2}: Constant, program notation "DEGTAB +2", scale factor B0, octal value 16314_8 31463_8, corresponding to decimal 0.45. Value equivalent to 45/100, to convert from B-3 revolutions to XX.XXX°.

K_{himin}: Single precision constant, program notation "HIMINCON", scale factor B0, value 23346_8. Value corresponds to $(0.6 + 2^{-7})$.

K_{hisec}: Single precision constant, program notation "HISECON", scale factor B0, value 23147_8. Value corresponds to $(0.6 + 2^{-14})$.

K_{hrcn1}: Constant, program notation "HRCON1", scale factor B-14, value 0.16384. Value corresponds to $10^{-5} \times 2^{14}$.

K_{hrcon}: Constant, program notation "HRCON", scale factor B28, units centi-seconds. Value is 00025_8 37100_8, corresponding to 360,000 (or 3600 seconds).

K_{idtb_i}: Table of constants for mixed noun information, program notation "IDADDTAB", giving address and scaling routine information. See information below.

K_{mincon}: Single precision constant, program notation "MINCON", scale factor B14, units centi-seconds. Value is 13560_8, corresponding to decimal 6000 (or 60 seconds).

K_{mncn1}: Constant, program notation "MINCON1", scale factor B-2, value 02104_8 10422_8, corresponding to $(1/60 \times 2^2 + 2^{-28})$, to give hours scaled B14 in MPAC+0 when return from "SEPMIN" (and fraction of an hour, B0, in MPAC+1).

K_{mncn2}: Constant, program notation "MINCON2", scale factor B0, value 00011_8 32445_8. Value corresponds to 60×10^{-5}.

K_{mscn3}: Constant, program notation "M/SCON3", scale factor B28, units centi-seconds. Value is 00025_8 37016_8, corresponding to 359,950 centi-seconds (or 59 minutes 59.5 seconds).

K_{mscn12}: Notation assigned to effect in program of constants "M/SCON1" and "M/SCON2", both single precision with octal values 77753_8 and 41126_8 respectively. The constants information, for program convenience, is stored in negative form (with magnitude of each decremented by one least increment for convenience in forming the absolute value). The net effective value in the program of the combined constant (scale factor B28, units centi-seconds) is 00025_8 36652_8, corresponding to 359,850 centi-seconds (59 minutes 58.5 seconds). A value of time of this value or more would be displayed in "M/SOUT" as 59 59, with appropriate sign.

K_{mxcn}: Single precision constant, program notation "MIXCON", scale factor B14, value 00050_8, corresponding to a noun of 40. Nouns of this value or above are considered "mixed nouns".

K_{ng1}: Single precision constant, program notation "NEG1", scale factor B-3, units revolutions, used to convert from twos complement to ones complement information. Value is $- 2^{-14}$ (minus one least increment).

K_{ngp2}: Single precision constant, program notation "NEG.2", value 71527_8. Octal value equivalent to $- 6250_8$: since the constant is added to information scaled XX.XXX°, value corresponds to 100 x (- 0.197754), or - 19.7754° (cf. K_{20b}).

K_{ntb_i}: Table of constants, program notation "NNADTAB", for loading NNADTEM. See information below.

K_{nty_i}: Table of constants, program notation "NNTYPTAB", for loading NNTYPTEM. See information below.

K_{rd_I}: See Data Input/Output.

K_{rndcn}: Constant, program notation "RNDCON -1", scale factor B28, units centi-seconds. Value is 00000_8 00062_8, corresponding to 50 centi-seconds (0.5 second).

K_{rtmtb_i}: Table of constants used to specify scaling routines for mixed nouns, program notation "RUTMXTAB". See information below (is used to load RUTMXTEM). First table cell is for noun 40.

K_{scn1}: Constant, program notation "SECON1", scale factor B-12, value $1.666666666E\text{-}4 \times 2^{12}$, corresponding to $(1/6000) \times 2^{12}$(to convert centi-seconds scaled B28 to minutes scaled B16, cf. HITEMOUT).

K_{scn2}: Constant, program notation "SECON2", scale factor B0, value 01727_8 01217_8. Value corresponds to 60×10^{-3}.

K_{sfin_0}: First of a set of input constants selected in "GTSFIN", located in consecutive cells starting at "SFINTAB". Value is 00006_8 03240_8, scale factor B28. Value corresponds to $10^5 \times 2^{-28}$, to convert from the fraction produced by "NUM" to an integer with scale factor B28.

K_{sfin_1}: Constant, value 0, not assigned.

K_{sfin_2}: Constant, value 0, used to set initial condition for SFTEMP1 for use in "DEGINSF" and "OPDEGIN". The scaling routine itself selects the appropriate scaling constants.

K_{sfin_3}: Constant, value 10707_8 03435_8, scale factor B0. Value corresponds to one least increment more than (100 x 1/360), to convert from an input of XX.XXX° to B0 revolutions. Since there are 2^{21} gyro pulses per revolution, the constant could also be considered to convert to gyro pulses, scale factor B21.

K_{sfin_4}: Constant, scale factor B3, value 13070_8 34345_8. Value corresponds to one least increment more than $(1000 \times 1/360) \times 2^{-3}$, to convert from XXX.XX° to B3 revolutions (hence use Routine #10, "DPINSF4", to shift result left 3 for a scaling of B0 revolutions).

K_{sfin_5}: Constant, value 00005_8 21616_8, scale factor B14. Value corresponds to $(1000 \times 1/180) \times 2^{-14}$, to convert from XXX.XX° to B-1 revolutions (after performing a left shift of 14). Not used.

K_{sfin_6}: Constant, value 26113_8 31713_8, scale factor B0. Value corresponds to $10^5 \times 0.45359237 \times 2^{-16}$, to convert between XXXXX. pounds and B16 kilograms (single precision).

K_{sfin_7}: Constant, value 00070_8 20460_8, scale factor B0. Value corresponds to $10^3 \times 1852 \times 2^{-29}$, to convert between XXX.XX nmi and meters scaled B29 (there are 1852 meters in a nautical mile).

K_{sfin_8}: Constant, value 01065_8 05740_8, scale factor B0. Value corresponds to $10^4 \times 1852 \times 2^{-29}$, to convert between XXXX.X nmi and meters scaled B29 (there are 1852 meters in a nautical mile). See K_{sfot_8}.

K_{sfin_9}: Constant, value 11414_8 31463_8, scale factor B3. Value corresponds to $10^5 \times 10^{-2} \times 0.3048 \times 2^{-7} \times 2^{-3}$, for the net value to convert from XXXXX. feet/second to B10 meters/centi-second (hence use Routine #10, "DPINSF4", to shift result left 3 for scaling of B7 meters/centi-second).

$K_{sfin_{10}}$: Constant, value 07475_8 16051_8, scale factor B0. Value corresponds to $10^4 \times 10^{-2} \times 0.3048 \times 2^{-7}$, in order to convert between XXXX.X fps and meters/centi-second with scale factor B7.

$K_{sfin_{11}}$: Constant, value 00001_8 03434_8, scale factor B14. Value corresponds to $10^2 \times (1/90) \times 2^{-14}$, to convert from XX.XXX° to B-2 revolutions (after performing a left shift of 14 via Routine #3, "ARTHINSF").

$K_{sfin_{12}}$: Constant, value 00002_8 22245_8, scale factor B14. Value corresponds to $10^3 \times (3600/85.41) \times 2^{-14} \times 2^{-14}$ minus one least increment, to convert between XXX.XX° and B14 "CDU actuator pulses" (after performing a left shift of 14 via Routine #3, "ARTHINSF"). There are 85.41 arc seconds per CDU actuator pulse.

$K_{sfin_{13}}$: Constant, value 00014_8 35607_8, scale factor B14. Value corresponds to $10^7 \times 1.355817948 \times 2^{-20} \times 2^{-14}$, to convert between XXXXXbb. slug-feet^2 and B20 kilogram-meters^2 (after performing a left shift of 14 via Routine #3, "ARTHINSF"). The "bb" means that the input is in units of 100 slug-feet^2. Same constant could also be used to convert between XXXXXbb. foot-pounds and B20 newton-meters. Constant is not used (since functions are computed in "FIXCW" as determined from inputs of vehicle mass).

$K_{sfin_{14}}$: Constant, value 07606_8 06300_8, scale factor B3. Value corresponds to one least increment more than $10^5 \times (1/25766.1973) \times 2^{-1} \times 2^{-3}$, to convert between XXXXX. fps and B1 VSAT units (used in entry, where 1 VSAT = 25766.1973 fps), after performing a left shift of 3 via Routine #10, "DPINSF4".

$K_{sfin_{15}}$: Constant, value 16631_8 11307_8, scale factor B0. Value corresponds to $10^4 \times (1/21622.4965)$, to convert between XXXX.X nmi and B0 revolutions. The denominator conversion value corresponds to $2\pi \times 6373338 / 1852$, i.e. an earth radius equal to the value of K_{rpad} (see Burn Control) used to derive circumference.

$K_{sfin_{16}}$: Constant, value 12000_8 00000_8, scale factor B7. Value corresponds to $10^3 \times (1/25) \times 2^{-7}$, to convert between XXX.XX g's and B0 "G-units" (25 g's, as used in Entry Computations), after performing a left shift of 7 via Routine #5, "DPINSF2".

$K_{sfin_{17}}$: Constant, value 27176_8 14235_8, scale factor B0. Value corresponds to $10^4 \times (1/3441.3272) \times 2^{-2}$, to convert between XXXX.X nmi and radians scaled B2 (using the pad radius given for $K_{sfin_{15}}$).

$K_{sfin_{18}}$: Constant, value 30480×2^{-19}, scale factor B0. Value corresponds to $10^5 \times 0.3048 \times 2^{-19}$, to convert between XXXXX. feet and meters scaled B19 (there are 0.3048 meters in one foot).

$K_{sfin_{19}}$: Constant, value 30.48×2^{-7}, scale factor B7. Value corresponds to $10^4 \times 0.3048 \times 10^{-2} \times 2^0 \times 2^{-7}$, to convert between XXXX.X fps and B0 meters/centi-second (first term is for XXXX.X fps, second converts to meters, third converts to centi-seconds, fourth is for scaling of final answer, and fifth is scale factor of constant), after a left shift of 7 via Routine #5, "DPINSF2".

K_{sfot_0}: First of a set of output constants selected in "GTSFOUT", located in consecutive cells starting at "SFOUTAB". Value is 05174_8 13261_8, scale factor B0, with value corresponding to $10^{-5} \times 2^{14}$, to convert from an integer with scale factor B14 to XXXXX.

K_{sfot_1}: Constant, value 0, not assigned.

K_{sfot_2}: Constant, value 0, used to load SFTEMP1 with proper initial value for use in "DEGOUTSF" and "OPDEGOUT".

K_{sfot_3}: Constant, value 00714_8 31463_8, scale factor B7. Value corresponds to $(360) \times 10^{-2} \times 2^{-7}$, to convert from B0 revolutions to XX.XXX°. Since there are 2^{21} gyro pulses per revolution, the constant could also be considered to convert from gyro pulses scaled B21.

K_{sfot_4}: Constant, value 13412_8 07534_8, scale factor B0. Value corresponds to $(360) \times 10^{-3}$, to convert from B0 revolutions to XXX.XX°.

K_{sfot_5}: Constant, value 05605_8 03656_8, scale factor B0. Value corresponds to $(180) \times 10^{-3}$, to convert from B-1 revolutions to XXX.XX°. Constant is not used.

K_{sfot_6}: Constant, value 00001_8 16170_8, scale factor B14. Value corresponds to $2^{16} \times (1/0.45359237) \times 10^{-5} \times 2^{-14}$, to convert between B16 kilograms and XXXXX. pounds.

K_{sfot_7}: Constant, value 00441_8 34306_8, scale factor B14. Value corresponds to $2^{29} \times (1/1852) \times 10^{-3} \times 2^{-14}$, to convert between B29 meters and XXX.XX nmi.

K_{sfot_8}: Constant, value 07176_8 21603_8, scale factor B7. Value corresponds to $(2^{29}) \times (1/1852) \times 10^{-4} \times 2^{-7}$, to convert between B29 meters and XXXX.X nmi (there are 1852 meters in a nautical mile). For N73, converts from units of meters/100 (computed by P21) to XXXXXb. nmi.

K_{sfot_9} : Constant, value 15340_8 15340_8, scale factor B0 (equality of two halves of constant is correct). Value corresponds to $(100 \times 2^7/0.3048) \times 10^{-5}$, to convert from the navigation scaling of velocity (B7 meters/centi-second) to XXXXX. fps.

$K_{sfot_{10}}$: Constant, value 01031_8 21032_8, scale factor B7. Value corresponds to $(100 \times 2^7/0.3048) \times 10^{-4} \times 2^{-7}$ plus one least increment, to convert from the navigation scaling of velocity (B7 meters/centi-second) to XXXX.X fps.

$K_{sfot_{11}}$: Constant, value 34631_8 23146_8, scale factor B0. Value corresponds to $(90) \times 10^{-2}$, to convert from B-2 revolutions to XX.XXX°.

$K_{sfot_{12}}$: Constant, value 14340_8 24145_8, scale factor B0. Value corresponds to $(85.41/3600) \times 2^{14} \times 10^{-3}$, to convert between B14 "CDU actuator pulses" and XXX.XX°. There are 85.41 arc seconds per CDU actuator pulse.

$K_{sfot_{13}}$: Constant, value 02363_8 03721_8, scale factor B0. Value corresponds to $2^{20} \times (1/1.355817948) \times 10^{-7}$, to convert between B20 kilogram-meters^2 and XXXXXbb. slug-feet^2 (the "bb" means that output is in units of 100 slug-feet^2). Same constant could also be used to convert between B20 newton-meters and XXXXXbb. foot-pounds. Constant is not used (see $K_{sfin_{13}}$).

$K_{sfot_{14}}$: Constant, value 20373_8 02122_8, scale factor B0. Value corresponds to $2^1 \times 25766.1973 \times 10^{-5}$, to convert between B1 VSAT units and XXXXX. fps (one VSAT is 25766.1973 fps, used in entry).

$K_{sfot_{15}}$: Constant, value 00424_8 30446_8, scale factor B7. Value corresponds to $21622.4965 \times 10^{-4} \times 2^{-7}$, to convert between B0 revolutions and XXXX.X nmi (see $K_{sfin_{15}}$).

$K_{sfot_{16}}$: Constant, value 00631_8 23146_8, scale factor B0. Value corresponds to 25×10^{-3}, to convert between B0 "G-units" (25 g's, as used in entry computations) and XXX.XX g's.

$K_{sfot_{17}}$: Constant, value 00260_8 06213_8, scale factor B7. Value corresponds to $3441.3272 \times 2^{28} \times 10^{-4} \times 2^{-7}$, to convert between B2 radians and XXXX.X nmi (using pad radius, see $K_{sfin_{17}}$).

$K_{sfot_{18}}$: Constant, value 17.2010499×2^{-7}, scale factor B7. Value corresponds to $2^{19} \times (1/0.3048) \times 10^{-5} \times 2^{-7}$, to convert between B19 meters and XXXXX. feet (with a left shift of 7 places due to scaling of constant).

$K_{sfot_{19}}$: Constant, value 0.032808399, scale factor B0. Value corresponds to $2^0 \times 10^2 \times (1/0.3048) \times 10^{-4}$, to convert between B0 meters/centi-second and XXXX.X fps: first term is for original scaling, second converts to seconds, third converts to feet, and fourth is display scale.

K_{whecon}: Constant, program notation "WHOLECON", value 00006_8 03240_8, scale factor B28. Value corresponds to $10^5 \times 2^{-28}$ (to "compensate" for the scaling done in "NUM").

MIXBR: Single precision cell, scale factor B14, set in "LODNNTAB" to 1 for a "normal" noun and to 2 for a "mixed" noun.

NNADTEM: Temporary storage cell, single precision, loaded in "LODNNTAB" with the value of K_{ntb_I} corresponding to NOUNREG contents. See information below.

NNTYPTEM: Temporary storage cell, single precision, loaded in "LODNNTAB" with the value of K_{nty_I} corresponding to NOUNREG contents. See information below.

NOUNADD, NOUNREG: See Data Input/Output.

OVFINP: See Data Input/Output.

RUTMXTEM: Temporary storage cell, single precision, loaded in "LODNNTAB" with value of K_{rtmtb_I} for "mixed nouns" only. See information below.

SFTEMP1: Temporary storage cell used to contain the appropriate value of K_{sfin_I} or K_{sfot_I}, used for angle bias information (if any) in "DEGOUTSF" and "OPDEGOUT".

VERBSAVE: See Data Input/Output.

YREG, YREGLP: See Data Input/Output (YREGLP described for LPREG).

ZREG, ZREGLP: See Data Input/Output (ZREGLP described for LPREG).

Noun Table Interpretation

"Normal" Nouns
MIXBR = 1

K_{nty} bits 15-11 contain the "component code number", interpreted as follows:

Bit 15 is 1 if no loading of information by use of the noun with verbs 24 or 25 is allowed.

Bit 14 is 1 if only decimal input/output by use of the noun is allowed (i.e. no octal verbs may be used).

Bit 13 is not assigned.

Bits 12-11 give information on the number of components:

00_2 for one component

01_2 for two components

10_2 for three components

K_{nty} bits 10-6 contain the "scale factor routine code number", used in "DECDSP3" and "PUTDCSF2" to transfer to the proper scaling routine.

K_{nty} bits 5-1 contain the "scale factor constant code number", used in "GTSFOUT" and "GTSFIN" to select the proper scaling constant.

K_{ntb} gives the machine address information with the following interpretations:

+0 if noun not assigned.

-0 if previous address to be incremented by +1.

-1 if a channel is to be loaded or read (channel number is supplied as another input).

$<$-1 (usually 40000_8) if an octal erasable memory address is to be supplied as another input.

$>$+0 if the octal erasable memory address is given (for the first component).

"Mixed" Nouns
MIXBR = 2

K_{nty} bits 5-1, 10-6, and 15-11 contain the "scale factor constant code number", used in "GTSFOUT" and "GTSFIN", for component #1, #2, and #3 respectively.

K_{ntb} bits 15-11 contain the "component code number", with the same bit assignments as for bits 15-11 of K_{nty} for normal nouns.

K_{ntb} bits 10-1 contain the relative address (with respect to the start of the K_{idtb} table, program notation "IDADDTAB") of the information in that table for the first component of the noun. Is 3(NOUNREG -40).

K_{idtb} gives the octal erasable memory address for the individual component (if the noun is three components, three consecutive cells are used).

K_{rtmtb} bits 5-1, 10-6, and 15-11 contain the "scale factor routine code number", used in "DECDSP3" and "PUTDCSF2", for component #1, #2, and #3 respectively.

Notes for Noun Table Information

1. A decimal display of "hr,mn,sc" appears as: 00XXX. hr
   000XX. mn
   0XX.XX sc

2. A decimal single-register display of "mn, ,sc" appears with minutes in the first two digits of the register and seconds in the last two digits. The middle (third) digit is blank. Maximum magnitude is 59 59.

3. Vector-type quantities are displayed with the first (e.g. X) component in R1, the second component in R2, and the third in R3.

4. Single component nouns appear in R1 only.

5. If an output quantity is larger than the capacity of the display register scaling, it generally will be displayed modulo that capacity: this assumes, of course, that the basic cell itself as stored in memory has not overflowed. If velocity increment of 12000 fps experienced on an XXXX.X fps scale for display, it would be expected to show 2000(.)0. This arises from the fact that the K_{sfot} constants convert the information into the range 0 - 0.99999, with subsequent display output generated by multiplying by 10 and using the integral part of the result (in "DSPDCWD1"). Multiplication by the K_{sfot} constant takes place before any scaling shifts.

Noun Table Information

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
00	+0			0	0	0	---	Not assigned.
01	40000_8			3	1	0	.XXXXX	Address supplied.
02	40000_8			3	3	0	XXXXX.	Address supplied.
03	40000_8			3	2	2	XXX.XX°	Address supplied.
04	+0			0	0	0	---	Not assigned.
05	$DSPTEM1_{dp}$			1	10	4	XXX.XX°	Angle error.
06	OPTION1 OPTION2			2	0	0	Octal	Option codes.
07	XREG YREG ZREG			3	0	0	Octal Octal Octal	Address of word. Bits to be changed. If ≤ 0, reset; if > 0, set bits: see "ABCLOAD" (use only with V25).
08	ALMCADR ALMCADR+1 ERCOUNT			3	0	0	Octal	Alarm data.
09	FAILREG			3	0	0	Octal	Alarm codes.
10	-1			1	0	0	Octal	Channel supplied.
11	T_{csi}		x	3	8	0	hr,mn,sc	CSI ignition time.
12	OPTIONX OPTIONX+1			2	0	0	Octal	Option codes.
13	T_{cdh}		x	3	8	0	hr,mn,sc	CDH ignition time.
14	VCdO			1	10	9	XXXXX. fps	P15 desired velocity.
15	-0			1	0	0	Octal	Increment address.
16	DSPTEMX		x	3	8	0	hr,mn,sc	Time of event.
17	CPHI$\underline{X}$			3	2	2	XXX.XX°	V63 FDAI base angles (V60E loads with N20).
18	THETA$\underline{D}$			3	2	2	XXX.XX°	Ball angles for attitude maneuver.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
19	+0			0	0	0	---	Not assigned.
20	CDU			3	2	2	XXX.XX^{o}	Present ICDU angles.
21	PIPA			3	3	0	XXXXX. cnt	Accelerometer cells.
22	THETAD			3	2	2	XXX.XX^{o}	Desired ICDU angles.
23	+0			0	0	0	---	Not assigned.
24	$DSPTEM2+1_{dp}$		x	3	8	0	hr,mn,sc	Delta time for clock.
25	DSPTEM1			3	3	0	XXXXX.	Checklist information.
26	N26dPRI N26d2CAD N26d2CAD+1			3	0	0	Octal	Priority/Delay and 2CADR address for V30 and V31.
27	SMODE			1	3	0	XXXXX.	Computer Self-Test switch.
28	+0			0	0	0	---	Not assigned.
29	DSPTEM1		x	1	2	2	XXX.XX^{o}	$\underline{X}_{sm}$ launch azimuth.
30	DSPTEM1			3	3	0	XXXXX.	Target codes.
31	AGEOFW		x	3	8	0	hr,mn,sc	Time of r/v W matrix.
32	mTPER		x	3	8	0	hr,mn,sc	Time from pericenter.
33	T_{ig}		x	3	8	0	hr,mn,sc	Time of "ignition".
34	$DSPTEM1_{dp}$		x	3	8	0	hr,mn,sc	Time of event.
35	T_{togo}		x	3	8	0	hr,mn,sc	Time from event.
36	T_{now}		x	3	8	0	hr,mn,sc	AGC clock.
37	T_{tpi}		x	3	8	0	hr,mn,sc	TPI ignition time.
38	T_{et}		x	3	8	0	hr,mn,sc	State vector time.
39	T3TOT4		x	3	8	0	hr,mn,sc	Transfer time.
40		x	x	3				
	T_{togo}				9	0	mn, ,sc	Time from event.
	VGDISP				7	10	XXXX.X fps	$\lvert\underline{V}_g\rvert$ value.
	DVTOTAL				7	10	XXXX.X fps	Velocity accumulated.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
41				2				
	$DSPTEM1_{sp}$				2	2	XXX.XX^o	Target azimuth.
	$DSPTEM1{+}1_{sp}$				3	11	XX.XXX^o	Target elevation.
42			x	3				
	HAPO				7	8	XXXX.X nmi	Apo. altitude.
	HPER				7	8	XXXX.X nmi	Per. altitude.
	VGDISP				7	10	XXXX.X fps	Required velocity change.
43			x	3				
	LAT				10	4	XXX.XX^o	Latitude.
	LONG				10	4	XXX.XX^o	Longitude.
	ALT				7	8	XXXX.X nmi	Altitude.
44		x	x	3				
	HAPOX				7	8	XXXX.X nmi	Apo. altitude.
	HPERX				7	8	XXXX.X nmi	Per. altitude.
	TFF				9	0	mn, ,sc	Time from interface altitude.
45		x	x	3				
	VHFCNT/ TRKMKCNT				12	0	VH, ,TR	VHF marks (D1 and D2). Optics marks (D4 & D5).
	T_{togo}				9	0	mn, ,sc	Time from event.
	pMGA				10	4	XXX.XX^o	Predicted middle gimbal angle (if +).
46				2				
	DAPDATR1				0	0	Octal	DAP code word #1.
	DAPDATR2				0	0	Octal	DAP code word #2.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
47			x	2				
	CSMMASS				11	6	XXXXX. lbs	CSM mass.
	LEMMASS				11	6	XXXXX. lbs	LM mass.
48			x	2				
	PACTOFF				3	12	XXX.XX°	Pitch SPS trim.
	YACTOFF				3	12	XXX.XX°	Yaw SPS trim.
49			x	3				
	N49DISP				4	7	XXX.XX nmi	Position change.
	N49DISP+2				7	10	XXXX.X fps	Velocity change.
	N49DISP+4				3	0	XXXXX.	Source code (1 for optics, 2 for VHF).
50		x	x	3				
	RSPmRREC				7	15	XXXX.X nmi	Splash error.
	HPERX				7	8	XXXX.X nmi	Per. Altitude.
	TFF				9	0	mn, ,sc	Time from interface altitude.
51			x	2				
	RHOSB				10	4	XXX.XX°	S-band antenna pitch.
	GAMMASB				10	4	XXX.XX°	S-band antenna yaw.
52				1				
	ACTCENT				10	4	XXX.XX°	Active vehicle central angle.
53			x	3				
	RANGE				4	7	XXX.XX nmi	Range from target.
	RRATE				7	10	XXXX.X fps	Range rate.
	RTHETA				10	4	XXX.XX°	Angle Phi (R34).

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
54			x	3				
	RANGE				4	7	XXX.XX nmi	Range from target.
	RRATE				7	10	XXXX.X fps	Range rate.
	RTHETA				10	4	XXX.XX°	Angle Theta (R31/P79).
55			x	3				
	NN1				3	0	XXXXX.	Per. code.
	ELEV				10	4	XXX.XX°	Elevation angle.
	CENTANG				10	4	XXX.XX°	Passive vehicle central angle.
56			x	2				
	RTEGAM2D				10	4	XXX.XX°	P37 desired flight path angle.
	RTEDVD				10	9	XXXXX. fps	P37 desired velocity change.
57				0				
	+0				7	0	---	Not assigned.
58			x	3				
	POSTTPI				7	8	XXXX.X nmi	Per. altitude after burn.
	DELVTPI				7	10	XXXX.X fps	Delta-V for burn.
	DELVTPF				7	10	XXXX.X fps	Delta-V for final phase.
59			x	3				
	DVLOS				7	10	XXXX.X fps	Delta-V in line-of-sight coordinates.
60			x	3				
	GMAX				3	0	XXX.XX g	Max. drag predicted.
	VPRED				10	9	XXXXX. fps	Predicted velocity 400 kft above Fischer.
	GAMMAEI				10	4	XXX.XX°	Predicted flight path angle with VPRED.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
61			x	3				
	LATSPL				10	4	XXX.XX^{o}	Target latitude.
	LNGSPL				10	4	XXX.XX^{o}	Target longitude.
	HEADSUP				3	0	XXXXX.	Heads up/down.
62			x	3				
	VMAGI				10	9	XXXXX. fps	Inertial velocity.
	HDOT				10	9	XXXXX. fps	Altitude rate.
	ALTI				7	8	XXXX.X nmi	Altitude above base radius magnitude.
63		x	x	3				
	RTGO				7	15	XXXX.X nmi	Range from EMS altitude to splash.
	VIO				10	9	XXXXX. fps	Predicted velocity at EMS altitude.
	TTE				9	0	mn, ,sc	Time from EMS altitude.
64			x	3				
	D				5	16	XXX.XX g	Drag acceleration.
	VMAGI				10	9	XXXXX. fps	Inertial velocity.
	RTGON67				7	15	XXXX.X nmi	Range to target.
65			x	3				
	T_{st}				8	0	hr,mn,sc	Sampled AGC clock.
66			x	3				
	ROLLC				10	4	XXX.XX^{o}	Commanded roll angle.
	LATANG				7	17	XXXX.X nmi	Cross-range error.
	DNRNGERR				7	15	XXXX.X nmi	Down-range error.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
67			x	3				
	RTGON67				7	15	XXXX.X nmi	Range to target.
	LAT				10	4	XXX.XX°	Latitude.
	LONG				10	4	XXX.XX°	Longitude.
68			x	3				
	ROLLC				10	4	XXX.XX°	Commanded roll angle.
	VMAGI				10	9	XXXXX. fps	Inertial velocity.
	RDOT				10	14	XXXXX. fps	Altitude rate.
69			x	3				
	ROLLC				10	4	XXX.XX°	Commanded roll angle.
	Q7				5	16	XXX.XX g	Drag at skip-out.
	VL				10	14	XXXXX. fps	Skip-out velocity.
70				3				
	STARCODE				0	0	Octal	Body code.
	LANDMARK				0	0	Octal	Landmark data.
	HORIZON				0	0	Octal	Horizon data.
71				3				
	STARCODE				0	0	Octal	Body code.
	LANDMARK				0	0	Octal	Landmark data.
	HORIZON				0	0	Octal	Horizon data.
72	+0			0	0	0	---	Not assigned.
73				3				
	P21ALT				7	8	XXXXXb. nmi	Altitude (P21 output m/100).
	P21VEL				10	9	XXXXX. fps	Velocity.
	P21GAM				10	4	XXX.XX°	Flight path angle.
74				3				
	ROLLC				10	4	XXX.XX°	Commanded roll angle.
	VMAGI				10	9	XXXXX. fps	Inertial velocity.
	D				5	16	XXX.XX g	Drag acceleration.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
75		x	x	3				
	DIFFALT				7	8	XXXX.X nmi	CDH Delta Altitude.
	T1TOT2				9	0	mn, ,sc	CDH-CSI/TPI-CDH.
	T2TOT3				9	0	mn, ,sc	TPI-CDH/TPI-NOMTPI.
76-77	+0			0	0	0	---	Not assigned.
78			x	3				
	UTYAW				10	4	XXX.XX°	P20 "yaw" angle.
	UTPIT				10	4	XXX.XX°	P20 "pitch" angle.
	AZIMANGL				10	4	XXX.XX°	P20 "azimuth" angle.
79			x	2				
	RATEPTC				3	11	X.XXXX°/sec	Rate ("R67START" divides by 10), P20 opt. #2.
	DBPTC				2	2	XXX.XX°	Deadband for P20.
80		x	x	3				
	T_{togo}				9	0	mn, ,sc	Time from event.
	VGDISP				10	9	XXXXX. fps	$\lvert \underline{V}_g \rvert$ value.
	DVTOTAL				10	9	XXXXX. fps	Velocity accumulated.
81			x	3				
	DELVLV$\underline{C}$				7	10	XXXX.X fps	Delta-$\underline{V}$ in local vert. coordinates.
82			x	3				
	DELVO$\underline{V}$				7	10	XXXX.X fps	Delta-$\underline{V}$ in local vert. coordinates.
83			x	3				
	DELVIM$\underline{U}$				7	10	XXXX.X fps	Delta-$\underline{V}$ in control coordinates.
84			x	3				
	DELVO$\underline{V}$				7	10	XXXX.X fps	Delta-$\underline{V}$ of other vehicle.
85			x	3				
	$\underline{V}_{gbody}$				7	10	XXXX.X fps	$\underline{V}_g$ in control coordinates.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
86			x	3				
	DELVLVC				10	9	XXXXX. fps	Delta-V in local vert. coordinates.
87				2				
	MRKBUF1+3$_{sp}$				2	2	XXX.XX^{o}	Optics shaft mark.
	MRKBUF1+5$_{sp}$				6	2	XX.XXX^{o}	Optics trunnion mark.
88			x	3				
	STARSAV3				13	0	.XXXXX	"Planet" vector.
89			x	3				
	LAT				7	3	XX.XXX^{o}	Lat. of landmark.
	LANDLONG				7	3	XX.XXX^{o}	½ Long. of landmark.
	LANDALT				4	7	XXX.XX nmi	Alt. of landmark.
90			x	3				
	YCSM				4	7	XXX.XX nmi	Active out-of-plane pos.
	YDOTC				7	10	XXXX.X fps	Active out-of-plane vel.
	YDOTL				7	10	XXXX.X fps	Pass. out-of-plane vel.
91				2				
	CDUS				2	2	XXX.XX^{o}	Optics shaft angle.
	CDUT				6	2	XX.XXX^{o}	Optics trunnion angle.
92				2				
	SAC				2	2	XXX.XX^{o}	Desired optics shaft.
	PAC				6	2	XX.XXX^{o}	Desired optics trunnion.
93				3				
	OGC				7	3	XX.XXX^{o}	Gyro torquing angles.
94				2				
	MRKBUF1+3$_{sp}$				2	2	XXX.XX^{o}	Alternate LOS shaft.
	MRKBUF1+5$_{sp}$				6	2	XX.XXX^{o}	Alternate LOS trunnion.

Noun	Cell	No Load	Dec. Only	Number	Routine	Constant	Decimal Display	Quantity
95				3				
	T_{togo}				9	0	mn, ,sc	Time from event.
	VGTLI				10	9	XXXXX. fps	P15 $\lvert \underline{V}_g \rvert$.
	VMAGI				10	9	XXXXX. fps	Inertial velocity.
96			x	3				
	RANGE				4	7	XXX.XX nmi	CSM out-of-plane pos.
	RRATE				7	10	XXXX.X fps	CSM out-of-plane vel.
	RRATE2				7	10	XXXX.X fps	LM out-of-plane vel.
97				3				
	$DSPTEM\underline{1}_{sp}$				3	0	XXXXX.	System test inputs.
98				3				
	$DSPTEM2_{sp}$				3	0	XXXXX.	System test results.
	$DSPTEM2+1_{sp}$				1	0	.XXXXX	System test results.
	$DSPTEM2+2_{sp}$				3	0	XXXXX.	System test results.
99			x	3				
	WWPOS				7	18	XXXXX. ft	Position W-matrix error/initialization.
	WWVEL				5	19	XXXX.X fps	Velocity W-matrix error/initialization.
	WWOPT				3	0	XXXXX.	Option code.

Note that N95 is <u>not</u> "No Load/Decimal Only".

<u>Quantities in Noun Tables</u>

ACTCENT: See Rendezvous Computations. N52

AGEOFW: See Measurement Incorporation. N31

ALMCADR: See General Program Control. N08

ALT: See Coordinate Transformations. N43

ALTI: See Boost Computations. N62

AZIMANGL: See Orbital and Rendezvous Navigation. N78

CDU: Major Variable. N20

CDUS, CDUT: See Optics Computations. N91

CENTANG: See Burn Control. N55

CPHIX: See Digital Autopilot RCS Routines. N17

CSMMASS: See Digital Autopilot Interface Routines. N47

D: See Entry Computations. N64, N74

DAPDATR1, DAPDATR2: See Digital Autopilot Interface Routines. N46

DBPTC: See Orbital and Rendezvous Navigation. N79

DELVIMU: See Display Computations. N83

DELVLVC: See Burn Control. N81, N86

DELVOV: See Burn Control. N82, N84

DELVTPF, DELVTPI: See Burn Control. N58

DIFFALT: See Rendezvous Computations. N75

DNRNGERR: See Entry Computations. N66

DSPTEM1: Major Variable. N05, N25, N29, N30, N34, N41, N97

DSPTEM2: Major Variable. N24, N98

DSPTEMX: See Display Computations. N16

DVLOS: See Burn Control. N59

DVTOTAL: See General Program Control. N40, N80

ELEV: See Rendezvous Computations. N55

ERCOUNT: See Testing Routines. N08

FAILREG: See General Program Control. N09

GAMMAEI: See Display Computations. N60

GAMMASB: See Display Computations. N51

GMAX: See Display Computations. N60

HAPO: See Burn Control. N42

HAPOX: See Display Computations. N44

HDOT: See Boost Computations. N62

HEADSUP: See Entry Preparation. N61

HORIZON: See Measurement Incorporation. N70, N71

HPER: See Burn Control. N42

HPERX: See Display Computations. N44, N50

LANDALT: See Orbital and Rendezvous Navigation. N89

LANDLONG: See Orbital and Rendezvous Navigation. N89

LANDMARK: See Orbital and Rendezvous Navigation. N70, N71

LAT: See Coordinate Transformations (tag also LANDLAT). N43, N67, N89

LATANG: See Entry Computations (tag also XRNGERR). N66

LATSPL: See Display Computations. N61

LEMMASS: See Digital Autopilot Interface Routines. N47

LNGSPL: See Display Computations. N61

LONG: See Coordinate Transformations. N43, N67

MRKBUF1+3: See Optics Computations. N87, N94

MRKBUF1+5: See Optics Computations. N87, N94

mTPER: See Display Computations. N32

N26d2CAD, N26d2CAD+1, N26dPRI: See Data Input/Output. N26

N49DISP, N49DISP+2, N49DISP+4: See Measurement Incorporation. N49

NN1: See Rendezvous Computations. N55

OG<u>C</u>: See Coordinate Transformations. N93

OPTION1, OPTION2: See Display Interface Routines. N06

T_{ig}: Major Variable. N33

T_{now}: Major Variable. N36

T_{st}: See Data Input/Output. N65

T_{togo}: See Burn Control. N35, N40, N45, N80, N95

T_{tpi}: See Rendezvous Computations. N37

T1TOT2, T2TOT3: See Rendezvous Computations. N75

T3TOT4: See Return to Earth Computations. N39

TFF: See Display Computations. N44, N50

THETA$\underline{D}$: Major Variable. N18, N22

TRKMKCNT: See Measurement Incorporation. N45

TTE: See Display Computations. N63

UTPIT, UTYAW: See Orbital and Rendezvous Navigation. N78

$\underline{V}_{gbody}$: See Burn Control. N85

VCdO: See Boost Computations. N14

VGDISP: See Burn Control. N40, N42, N80

VGTLI: See Boost Computations. N95

VHFCNT: See Measurement Incorporation. N45

VIO: See Display Computations. N63

VL: See Entry Computations. N69

VMAGI: See Boost Computations/Entry Computations. N62, N64, N68, N74, N95

VPRED: See Display Computations. N60

WWOPT, WWPOS, WWVEL: See Measurement Incorporation. N99

XREG: See Data Input/Output. N07

YACTOFF: See Digital Autopilot TVC Routines. N48

YCSM, YDOTC, YDOTL: See Burn Control. N90

YREG: See Data Input/Output. N07

ZREG: See Data Input/Output. N07

Internal Noun Uses

Listed below are the routines which cause the values of particular nouns to be displayed, together with the associated verb used for the initial display generation (which is sometimes written over with another verb).

Noun	Using Routine (Verb)
01	"OHWELL1" (21); "OHWELL2" (21); "SOPTION" (05)
02	"UPVERIFY" (21)
03	Manual initiation only (angle data, address-to-be-specified)
05	"R54" (06)
06	See Checklist and Option Codes
07	Manual initiation only (with V25, to change flag/channel bits)
08	Manual initiation only (Alarm data)
09	See the "D" Error Codes (used with V05)
10	Manual initiation only (channel-to-be-specified)
11	"P31" (06); "P72" (06)
12	See Checklist and Option Codes
13	"P73" (06)
14	"P15JOB" (06)
15	Manual initiation only (increment machine address)
16	"R36" (06); "V82GOFF1" (06)
17	Manual initiation only (V63 FDAI base angles)
18	"TOBALL" (06); "TOBALL" (06 replaced by 50); "V89RECL" (06)
20	"GYCRS" (16)
21	Manual initiation only (PIPA)
22	"IMUATTCK" (25); "P51A" (06); "P52D" (06); "P62.1" (06); "R62DISP" (06); "UPCONTRL" (06); "VBCOARK" (25)
24	"ALINTIME" (25)
25	See Checklist and Option Codes

Noun	Using Routine (Verb)
26	Manual initiation only (verb 30 and 31 parameters)
27	Manual initiation only (computer self-test switch)
29	"AZMTHCG1" (06)
30	"GCOMPVER" (05, written over by V06N41)
31	Manual initiation only (time of last r/v W matrix initialization)
32	Manual initiation only (time from pericenter computed in R30)
33	"P15JOB" (06); "P30" (06); "P31" (06); "P36A" (06); "P37" (06); "P37E" (06); "P76ER77" (06)
34	"PASSOUT" (06); "P20OPT" (06); "P21PROG1" (06); "P52B" (06)
35	Manual initiation only (h,m,s display of e.g. R1 of N40)
36	Manual initiation only (computer clock)
37	"P31" (06); "P34/P74C" (06); "P72" (06); "P74" (06)
38	Manual initiation only (state vector time, T_{et})
39	"RTEVN" (06)
40	"CLOCKJOB" (06 replaced by 97 or 99); "POSTBURN" (16); "P40SXTY" (06); "TIG-0" (06); "TIGAVEG" (06); "V97E" (06); "V97P" (06); "V99P" (06)
41	"GCOMPVER" (06, after N30 loads R3)
42	"P30" (06)
43	"LONGPASS" (06, R1 and R3 blanked); "PASSOUT" (06); "P21PROG2" (06)
44	"V82CALL" (16); "V82GOFLP" (16)
45	"PROG22" (06, R1 and R2 blanked); "P30" (16); "R23CSM1" (16 replaced by 53); "VN1645" (16)
46	"DONOUN46" (04)
47	"DONOUN46" (06)
48	"DONOUN46" (06)
49	"P23.85" (06, R3 blanked); "RENDISP2" (06, priority display); "S22BOX12" (06, R3 blanked)
50	Manual initiation only (optional R30 display, R1 computed P00/P11)

Noun	Using Routine (Verb)
51	"SBANDANT" (06, R3 blanked)
52	Manual initiation only (central angle of transfer computed in P34/P74 and P35/P75)
53	"R31CALL" (16)
54	"R31CALL" (16)
55	"P31" (06); "P34/P74C" (06); "P72" (06); "P74" (06)
56	Manual initiation only (P37 targeting data)
58	"P34/P74C" (06)
59	Manual initiation only (line-of-sight velocity increment)
60	"NEWRNVN" (06); "P37" (06, R1 blanked); "RTEVN" (06, R1 blanked)
61	"P61" (06); "P62.1" (06); "RTEVN" (06, R3 blanked)
62	"VHHDOT" (06)
63	"NEWRNVN" (16)
64	"P63" (06)
65	Manual initiation only (sampled computer clock)
66	"PREFINAL" (06)
67	"P67.1" (16)
68	Manual initiation only (entry quantities)
69	"P65.1" (16)
70	"PROG22A" (05, R1 and R3 blanked); "P23" (05); "R51DSPA" (01, R2 and R3 blanked); "V1N70DSP" (01)
71	"DOV5N71" (05, R1 and R3 blanked); "P23.60" (05); "R53C1" (01)
73	Manual initiation only (quantities computed in P21)
74	"INITROLL" (06)
75	"P32/P72C" (06); "P33/P73B" (06)
78	"DOV6N78" (06); "V89CALL" (06, R3 blanked)

Noun	Using Routine (Verb)
79	"DOV6N78" (06)
80	Manual initiation only (same as N40, but R2 and R3 different scaling)
81	"N90/N81" (06); "P30" (06); "P32/P72C" (06); "P33/P73B" (06); "P76ER77" (06); "RTEVN" (06); "S34/35.5" (06)
82	"P32/P72C" (06)
83	"P47BODY" (16)
84	"P76ER77" (06)
85	"P40SXTY" (06); "TIGAVEG" (16); "TIGNOW" (16)
86	Manual initiation only (same as N81, but different scaling)
87	"MARKDISP" (06, R1 and R3 blanked)
88	"PLANET" (06); "P23N7071" (06); "V1N70DSP" (06)
89	"P22SUBRB" (06); "P52B" (06); "S22I=N" (06)
90	"N90/N81" (06); "P32/P72C" (06); "P33/P73B" (06)
91	Manual initiation only (optics CDU angles)
92	"R53CHK" (06); "VBCOARK" (24)
93	"GCOMPVER" (06); "IMUFINEK" (25); "R55" (06)
94	"R23CSM" (06); "R56" (06)
95	"POSTTLI" (16); "P15JOB" (06); "TIGAVEG" (06)
96	"R36" (06)
97	Manual initiation only (DSPTEM1 cells for system test inputs)
98	"SHOW" (06)
99	"GOTOPOOH" (37, which then blanks noun register); "V67CALL" (06)

Optics Computations

OPTTEST Entered from "PROCEEDE" every 0.24 seconds

TS = CDUS (Tag here "OPTDRIVE")

$TS_1 = |TS| - K_{45dg}$

If $TS_1 \leq 0$:

ZONE = 0

If $TS_1 > 0$:

If ZONE = 0:

ZONE = TS

If OPTIND $\leq$ -0:

If OPTIND $<$ -0:

Set bit 8(TVC Enable) of channel 12 = 0

Resume

If SWSAMPLE $<$ 0: (Zero optics mode)

Resume

If SWSAMPLE = 0: (Manual mode)

If bit 8(TVC Enable) of channel 12 = 0: (Tag here "TVCBCK")

Set bit 8(TVC Enable) of channel 12 = 1

Resume

If bit 10(ZROPTFIN) of OPTMODES = 0: (Tag here "RATEDRV1")

Perform "ALARM" (pattern 0120_8)

If bit 2(Enable Optics CDU Error Counters) of channel 12 = 0:

Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 1

Resume

COMMANDS = (DESOPTS - CDUS), rescaled to B1 revolutions. The ones complement difference of the twos complement numbers is formed, and a rounded shift employed in the rescaling from B-1 to B1 revolutions.

$TS = DESOPTT - CDUT$ (treated as ones complement numbers)

If $|TS| < 2^{-3}$ rev (45°):

COMMANDT = (DESOPTT - CDUT), rescaled to B-1 revolutions. The ones complement difference of the twos complement numbers is formed, and a rounded shift employed in the rescaling from B-3 to B-1 revolutions.

If $|TS| \geqslant 2^{-3}$ rev (45°):

COMMANDT = +MAX sgn TS

OPTIND = +0

$TS_1 = 0$ (ITEMP1 tag)

If $|CDUS| - K_{90dg} > 0$: (i.e. 2nd or 3rd quadrant)

If ZONE $\neq$ 0: (should be)

If sgn ZONE = sgn COMMANDS: (+0 is +, -0 is -)

$TS_2 = |DESOPTS|$

If sgn ZONE $\neq$ sgn COMMANDS:

$TS_2 = +MAX$

If $TS_2 - K_{90dg} \leqslant 0$: (i.e. DESOPTS 1st or 4th quad.)

COMMANDS = - COMMANDS

SRATE = 0

If SWSAMPLE = 0: (Manual mode; Tag "CMDSETUP")

CDUSCMD = SRATE - SOLD + (-0) (the -0 avoids loading (Tag "RATEDRV2")

CDUTCMD = TRATE - TOLD + (-0) counter cell with +0)

TOLD = TRATE

SOLD = SRATE

Set bits 12-11 (Gate outputs from CDUiCMD, i = T,S) of channel 14 = 1

Resume

Set bit 8(TVC Enable) of channel 12 = 0

Perform the following for i = S,T: (Tag here "CMDSET")

If COMMANDi = 0:

CDUiCMD = -0

If COMMANDi $\neq$ 0:

$TS_1 = TS_1 + 1$ (non-zero command required)

$TS = |COMMANDi| + K_{mxps1}$

If TS $>$ 0:

CDUiCMD = $- K_{mxps}$ sgn COMMANDi

If TS $\leq$ 0:

CDUiCMD = COMMANDi

If $TS_1 > 0$:

Set bits 12-11 (Gate outputs from CDUiCMD, i = T, S) of channel 14 = 1

Resume

OPTMON Entered from "PROCEEDE" every 0.48 seconds

TS = bit 7(Optics CDU Fail complement) of channel 30

If TS $\neq$ bit 7(OCDUFBIT) of OPTMODES:

Perform "OCDUFTST"

If OPTIND = -0:

Resume (note that bit 7 of OPTMODES not updated)

If OPTIND $<$ 0: (set -1 by e.g. "INITSUBA")

Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 0

Set bit 7(OCDUFBIT) of OPTMODES = TS

Set bits 5-4(OPMD1BIT, OPMD2BIT) of OPTMODES = bits 5-4 (Computer Control of Optics complement and Zero Optics Mode complement) of channel 33

If bits 5-4 of C31FLWRD $\neq 00_2$:

Set bits 5-4 of OPTMODES = bits 5-4 of C31FLWRD

If bits 5-4 of OPTMODES = 11_2:

SWSAMPLE = 0 (Manual mode)

If bits 5-4 of OPTMODES $\neq 11_2$:

    If bit 5(OPMD1BIT) of OPTMODES = 0:

        SWSAMPLE = 15   (Computer Control)

    If bit 5(OPMD1BIT) of OPTMODES = 1:

        SWSAMPLE = -1

If DESOPMOD > 0:   (previous cycle Computer Control; Tag "PROCESSW")

    If SWSAMPLE > 0:   (still Computer Control; Tag "CSCDES")

        DESOPMOD = SWSAMPLE

        Resume

    If SWSAMPLE < 0:   (from Computer Control to Zero)

        Proceed to "CSCTOZOP"

    Proceed to "CSCTOMAN"   (from Computer Control to Manual)

If DESOPMOD = 0:   (previous cycle Manual mode)

    If SWSAMPLE > 0: (from Manual to Computer Control; Tag "MANUDES")

        WTOPTION = 0

        ZOPTCNT = 0

        Proceed to "CSCTOMAN"

    If SWSAMPLE = 0:   (still Manual)

        WTOPTION = WTOPTION - 1, limited $\geq$ +0

        DESOPMOD = SWSAMPLE

        Resume

    If WTOPTION = 0:   (from Manual to Zero)

        Proceed to "CSCTOZOP"

    Proceed to second line of "CSCTOZOP"

If DESOPMOD < 0: (as it will) (previous cycle Zero optics)

If SWSAMPLE > 0: (from Zero to Computer Control; Tag "ZOPTDES")

If bit 3(ZOPTCS) of OPTMODES = 0: (Tag "ZTOCSC")

Proceed to "CSCTOMAN"

Perform "ALARM" (pattern 0116_8)

Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 0

Set bit 1(Zero Optics CDU) of channel 12 = 0

WTOPTION = 0

ZOPTCNT = 0

Proceed to "CSCTOMAN"

If SWSAMPLE = 0: (from Zero to Manual)

If bit 3(ZOPTCS) of OPTMODES = 0: (Tag "ZTOMAN")

Proceed to "CSCTOMAN"

Perform "ALARM" (pattern 0116_8)

WTOPTION = 11

Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 0

Set bit 1(Zero Optics CDU) of channel 12 = 0

Proceed to "CSCTOMAN"

If bit 3(ZOPTCS) of OPTMODES = 0: (still Zero)

DESOPMOD = SWSAMPLE

Resume

If ZOPTCNT > 0:

ZOPTCNT = ZOPTCNT - 1

DESOPMOD = SWSAMPLE

Resume

Set bit 1(Zero Optics CDU) of channel 12 = 1 (Tag "SETZOEND")

(If DESOPMOD < 0):

Call "ENDZOPT" in 0.20 seconds

DESOPMOD = SWSAMPLE

Resume

ENDZOPT

CDUS = 0

ZONE = 0

CDUT = $- K_{20degs}$

Set bit 1(Zero Optics CDU) of channel 12 = 0

Delay 0.20 seconds

Set bit 10(ZROPTFIN) of OPTMODES = 1

Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 0

Perform "OCDUFTST"

End of task

OCDUFTST

If bit 7(Optics CDU Fail complement) of channel 30 = 0:

If bit 2(OCDUINHT) of OPTMODES = 1:

Return

If bit 8 of DSPTAB+11 = 0:

Set bit 8(Tracker) of DSPTAB+11 = 1, and flag for output at next opportunity

Return

If bit 1(LMPTSTBT) of IMODES33 = 1:

Return

If bit 8 of DSPTAB+11 = 1:

Set bit 8(Tracker) of DSPTAB+11 = 0, and flag for output at next opportunity

Return

CSCTOZOP

ZOPTCNT = 32

WTOPTION = 0

Set bits 3-2 (ZOPTCS, OCDUINHT) of OPTMODES = 1

Set bit 8(TVC Enable) of channel 12 = 0

Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 0

DESOPMOD = SWSAMPLE

Resume

CSCTOMAN

If OPTIND $\geqslant$ +0:

TOLD = 0

SOLD = 0

Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 0

Call "ECENAB" in 0.06 seconds

DESOPMOD = SWSAMPLE

Resume

ECENAB

If SWSAMPLE = 0: (Manual mode)

Set bit 8(TVC Enable) of channel 12 = 1

Set bit 2(Enable Optics CDU Error Counters) of channel 12 = 1

End of task

SXTMARK

Perform "TESTMARK"

If MODREG = 22 or 24:

NUM8NN = 0

P22DEX = 0

MARKINDX = 5

If MODREG $\neq$ 22:

If MODREG $\neq$ 24:

MARKINDX = 1

OPTCADR = Return address (to routine calling "SXTMARK")

Proceed to "MKVB51"

TESTMARK   Entered from "R56", "R57C", and "SXTMARK"

If bits 3-2 of EXTVBACT $\neq 00_2$:

Proceed to "BAILOUT" (pattern 31211_8)

Set bit 2 of EXTVBACT = 1

Return

MKRELEAS   (tag also "MKRLEES")

Inhibit interrupts

OPTIND = -1

MARKINDX = 0

Set bit 4(MARKFLG) of FLAGWRD1 = 0

Release interrupts

Return

MKVB51

Perform "KLEENEX"

Proceed to "MKVBDSP"

MKVBDSP

TS = 5100_{vn}

Proceed to "GOMARK4": if terminate, proceed to "TERMSXT"
if proceed, proceed to "ENTANSWR"
otherwise, proceed to "MKVB5X"

ENTANSWR

Establish "ENDEXT" (priority 24_8)

Change priority of present job to 13_8 (allows "ENDEXT" to be executed)

Proceed to address specified by OPTCADR

MKVB5X

If MARKINDX $>$ 0:

Proceed to "MKVB51"

Proceed to "MKVB50"

MKVB50

DSPTEM1 = 00016_8

TS = 5025_{vn}

Proceed to "GOMARK4": if terminate, proceed to "TERMSXT"
if proceed, proceed to "ENTANSWR"
otherwise, proceed to "MKVB5X"

TERMSXT

Perform "CLEARMRK"

Perform "MKRELEAS"

If MODREG = 03:

Proceed to "GCOMP5"

Proceed to "GOTOPOOH"

MARKRUPT Entered after receipt of program interrupt #6, navigation panel DSKY key code or optics mark/mark reject

MKCDUT = CDUT

MKCDUS = CDUS

MKCDUY = CDU_y

MKCDUZ = CDU_z

MKCDUX = CDU_x

MKT2T1 = T_{now}

T_{st} = MKT2T1

If bit 6(Optics Mark) of channel 16 = 1:

TS = $C_{cduchkwd}$, limited $\gg$ 1 centi-second (tag here "MARKIT")

Call "MARKDIF" in TS centi-seconds

Resume

If bit 7(Optics Mark Reject) of channel 16 = 1:

Proceed to "MKREJECT"

TS_1 = bits 5-1 (DSKY input) of channel 16

If $TS_1 \neq 0$:

Proceed to "KEYCOM"

Perform "ALARM" (pattern 0113_8)

Resume

MARKDIF

If bit 14(P24FLAG) of FLAGWRD9 = 0:

If $C_{cduchkwd} > 0$:

If any $|MKCDUi - CDU_i| + K_{m3bt} > 0$: (i = X,Y,Z)

Perform "ALARM" (pattern 0121_8)

End of task

If bit 14(R21MARK) of FLAGWRD2 = 1: (Tag here is "MARKCONT")

Proceed to "PUTMARK"

If bit 12(P23CALIB) of FLAGWRD5 = 1:

MARKDOWN+i = MKj (i = 0-6; j = $T2T1_{dp}$, CDUY, CDUS, CDUZ, CDUT, CDUX)

Establish "MARKDISP" (priority 05_8)

Proceed to "PUTMARK"

If MARKINDX = 0:

Perform "ALARM" (pattern 0114_8)

End of task

MARKINDX = MARKINDX - 1 (Tag here is "MARK2")

Set bit 4(MARKFLG) of FLAGWRD1 = 1

If MODREG = 24:

MARKINDX = MARKINDX + 1 (restores original value)

Set bit 11(P22MKFLG) of FLAGWRD3 = 1

Set bit 3(P24MKFLG) of FLAGWRD2 = 1

If MODREG $\neq$ 24:

If MODREG $\neq$ 22:

Proceed to "PUTMARK"

NUM8NN = NUM8NN + 1

SVMRKDAT+i_{P22DEX} = MKj (i = 0-6; see above for j) (Tag here "VACSTOR")

If MODREG $\neq$ 24:

P22DEX = P22DEX + 7

Proceed to "MARKDONE"

If P22DEX = 28: (In P24 if get here)

TS = 0

If P22DEX $\neq$ 28:

TS = P22DEX + 7

P22DEX = TS

Proceed to "MARKDONE"

PUTMARK

MRKBUF1+i = MKj (i = 0-6; see above for j)

If bit 14(R21MARK) of FLAGWRD2 = 1:

End of task

Proceed to "MARKDONE"

MARKDONE

If MARKINDX = 0:

Establish "MK-VB5X" (priority 22_8)

End of task

MKREJECT

If bit 14(R21MARK) of FLAGWRD2 = 1:

If MRKBUF1 $\geqslant$ 0: (i.e. last mark not yet being processed by R22)

MRKBUF1 = -1

Resume

(If bit 14(R21MARK) of FLAGWRD2 = 1):

    If bit 7(R22CAFLG) of FLAGWRD9 = 1: (set by "REND1")

        Set bit 12(REJCTFLG) of FLGWRD10 = 1 (for "REND7" use)

    Resume

If bit 4(MARKFLG) of FLAGWRD1 = 0:

    Perform "ALARM" (pattern 0110_8)

    Resume

Set bit 4(MARKFLG) of FLAGWRD1 = 0 (Tag here "REJECT3")

If MODREG = 24:

    Set bit 3(P24MKFLG) of FLAGWRD2 = 0

    If P22DEX = 0:

        TS = 28

    If P22DEX $\neq$ 0:

        TS = P22DEX - 7

    $SVMRKDAT_{TS_{dp}} = - SVMRKDAT_{TS_{dp}}$ (complement time information)

If MODREG $\neq$ 24:

    MARKINDX = MARKINDX + 1 (Tag here "REJECT4")

    If MODREG = 22:

        NUM8NN = NUM8NN - 1

        P22DEX = P22DEX - 7

        $SVMRKDAT_{P22DEX_{dp}} = - SVMRKDAT_{P22DEX_{dp}}$ (complement time)

Establish "MKVBDSP" (priority 22_8)

Resume (Note that "KLEENEX" bypassed, so may have more than F V51 on DSKY, e.g. N25 and R1 = 00016_8 also)

R23CSM Established by "GOTOR23" for a V54E

Set bit 14(R21MARK) of FLAGWRD2 = 0

MRKBUF1 = -1

Change priority of present job to 27_8 (higher than R22)

TS = 0694_{vn}

Proceed to "GOXDSPF": if terminate, proceed to "R21END"
if proceed, proceed
otherwise, proceed to previous line

Proceed to "R23CSM1"

R23CSM1

TS = 5345_{vn}

Proceed to "MARKMONR": if terminate, proceed to "R21END"
if proceed, proceed to "R21END"
otherwise, proceed

Inhibit interrupts

$MRKBUF1_{dp} = T_{now}$

MRKBUF1+2 = CDU_y (MRKBUF1+3 and MRKBUF1+5 loaded by N94 in "R23CSM")

MRKBUF1+4 = CDU_z

MRKBUF1+6 = CDU_x

Release interrupts

Proceed to "R23CSM1" ("V86PERF", if done promptly, can be used to reject the mark)

R21END

Perform "KLEENEX"

MRKBUF1 = -1

Change priority of present job to 16_8 (allow R22 to finish if processing mark, with proper R21MARK bit value)

Set bit 14(R21MARK) of FLAGWRD2 = 1

Proceed to "ENDEXT"

R52 Entered from "PIKUP20","PROG22A","PROG24", "P23.57", and "R51"

Set bit 10(ADVTRK) of FLAGWRD8 = 0

SAVQR52 = Return address (enter here from "S22N7071"; Tag "R52VRB")

DESOPTT = CDUT

DESOPTS = CDUS

AOPOLD = T_{now}

OPTIND = +0

Set bit 6(SGTMK) of FLAGWRD0 = 0 (notation R53FLAG)

If bit 10 (LMTRG) of FLAGWRD1 = 1: (notation TARG1FLG)

Proceed to "R52H"

Set bit 15(TERMIFLG) of FLAGWRD7 = 0

Proceed to "R52C"

R52C

If SWSAMPLE > 0: (i.e. Computer Control of optics)

Proceed to "R52D"

If bit 6(SGTMK) of FLAGWRD0 = 0: (Tag here "R52M")

Establish "R53JOB" (priority 24_8)

If MODREG ≠ 24: (Tag here "R52G")

Proceed to "R52FA"

If PASSCNT > 0:

PASSCNT = PASSCNT - 1

Proceed to "R52D"

If bit 3(P24MKFLG) of FLAGWRD2 = 0: (new mark not yet available)

Proceed to "R52D"

If P22DEX = 0:

X1 = - ("SVMRKDAT" + 28)

If P22DEX $\neq$ 0: (NOTE that sampled at different times to check for zero and to compute X1, hence if get "5th" mark could have meaningless data in the 7 cells before start of SVMRKDAT)

X1 = - ("SVMRKDAT" - 7 + P22DEX)

MARKDATA = X1 (i.e.-address of last mark point) (Tag here "R52K")

TS = $E_{-X1_{dp}}$ (i.e. time tag of point)

If TS < 0: (meaning a mark reject received)

Proceed to "R52D"

S22TOFF = TS

T_{decl} = TS

Perform "CSMCONIC"

CSMPO$\underline{S}$ = $\underline{R}_{attl}$ (B29 earth, B27 moon)

X1 = MARKDATA

Perform "GETUM"

U$\underline{M}$ = T$\underline{S}$

ALPHA$\underline{V}$ = unitCSMPO$\underline{S}$

Perform "SETRE"

ERADM = ERADM + ALT

TS = - unitCSMPO$\underline{S}$ · U$\underline{M}$

TS_1 = ERADM

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift TS_1 left 2 places (to scale factor B27)

$$S22RHO = |CSMPOS| \left(TS - \sqrt{(TS_1 / |CSMPOS|)^2 - (1 - TS^2)} \right)$$

X78$\underline{9}$ = CSMPO$\underline{S}$ + S22RHO U$\underline{M}$

T$\underline{S}$ = X78$\underline{9}$

If bit 12(CMOONFLG) of FLAGWRD8 = 1:

Shift T$\underline{S}$ right 2 places (to B29)

ALPHA$\underline{V}$ = T$\underline{S}$

TS = S22TOFF

Perform "LAT-LONG"

LANDLONG = $\frac{1}{2}$ LONG

LANDALT = ALT

Set bit 14(NEWLMFLG) of FLAGWRD8 = 1

Set bit 3(P24MKFLG) of FLAGWRD2 = 0

PASSCNT = C_{nopass} - 1

Proceed to "R52D"

R52FA

TS = 0.50 second

Delay TS seconds (by putting job to sleep via "DELAYJOB")

If bit 10(LMTRG) of FLAGWRD1 = 1:

Proceed to "R52H"

If bit 15(TERMIFLG) of FLAGWRD7 = 1: (set by end of "R53")

Proceed to address specified by SAVQR52

Proceed to "R52C"

R52H (Entered only if tracking LM, from "R52" and "R52FA")

Perform "R61CSM"

If bit 5(TRACKFLG) of FLAGWRD1 = 0:

Proceed to address specified by SAVQR52

If bit 7(UPDATFLG) of FLAGWRD1 = 1:

Proceed to "R52D"

TS = 1.80 seconds

Proceed to second line of "R52FA"

R52D

TS = T_{now} + $K_{2p4secdp}$

If bit 14(P24FLAG) of FLAGWRD9 = 1:

TS = TS - $K_{p5secdp}$

AOPTIME = TS

If bit 10(LMTRG) of FLAGWRD1 = 1: (program notation TARG1FLG)

T_{decl} = AOPTIME (Tag here "LEM52")

Perform "LEMCONIC"

$STA\underline{R} = \underline{R}_{att}$

If bit 10(LMTRG) of FLAGWRD1 = 0:

If bit 9(LMKTRG) of FLAGWRD1 = 1: (program notation TARG2FLG)

If bit 10(ADVTRK) of FLAGWRD8 = 1: (Tag here "LMK52")

Proceed to "ADVTRACK"

TS = AOPTIME

Perform "LALOTORV"

$STA\underline{R} = ALPHA\underline{V}$

If bit 9(LMKTRG) of FLAGWRD1 = 0:

If STARIND = 0:

$T\underline{S} = STARSAV\underline{2}$

If STARIND > 0:

$T\underline{S} = STARSAV\underline{1}$

Proceed to "COM52"

T_{decl} = AOPTIME (tag here is "LMKLMCOM", for LM or landmark)

Perform "CSMCONIC"

$T\underline{S} = unit(STA\underline{R} - \underline{R}_{att})$

Proceed to "COM52"

<u>COM52</u>

$STA\underline{R} = unit(\left[REFSMMAT\right] T\underline{S})$

Perform "CDUTRIG"

Perform "CALCSXA"

If bit 7(CULTFLAG) of FLAGWRD3 = 1:

If bit 10(LMTRG) of FLAGWRD1 = 0: (Tag here "R52L")

$TS = 0404_8$

Perform "PRIOLARM": if terminate, proceed to "TERM52"
if proceed, skip next line
otherwise, skip next line

End of job

If MODREG $\neq$ 24:

Proceed to "R52FA"

TS = 0.05 second

Proceed to second line of "R52FA"

$PACTEMP = K_{50dgtr_{sp}}$

If bit 7(CULTFLAG) of FLAGWRD3 = 0:

If $(PAC - K_{50dgtr}) < 0$ and $(PAC - K_{20dgsmn}) \geqslant 0$:

PACTEMP = PAC

Skip next line

$PACTEMP = K_{50dgtr_{sp}}$

If bit 10(LMTRG) of FLAGWRD1 = 1: (Tag here "R52JA")

Proceed to "R52E"

If bit 14(P24FLAG) of FLAGWRD9 = 0:

Proceed to "R53CHK"

If bit 14(NEWLMFLG) of FLAGWRD8 = 0: (If bit is 1, have a new landmark position estimate and hence first-difference scheme could give false rate)

Proceed to "RATESUB"

Set bit 14(NEWLMFLG) of FLAGWRD8 = 0

AOPOLD = AOPTIME

Proceed to "R53CHK"

<u>R53CHK</u>

If bit 6(SGTMK) of FLAGWRD0 = 0:

$TS = 0692_{vn}$

Perform "GODSPR"

Proceed to "R52E"

R52E

DESOPTT = PACTEMP

DESOPTS = SAC

(note that interrupts not inhibited for these 2 lines, meaning that could get a "T4RUPT" drive with inconsistent desired angles; done correctly in "RATESUB")

If MODREG $\neq$ 24:

Proceed to "R52FA"

TS = 0.05 second

Proceed to second line of "R52FA"

R53JOB Established by "R52C"

Perform "R53"

End of job

TERM52 Entered for V34E response to 0404_8 display

Perform "KLEENEX"

Proceed to "TERMSXT"

RATESUB Entered from "COM52"

RATETEMP = (AOPTIME - AOPOLD), with sign agreement forced, scaled B24 cs

AOPOLD = AOPTIME

RATETEMP_{sp} = RATETEMP+1 (i.e. time difference, B10 cs)

SRTEMP = $(C_{shaftsf} / \text{RATETEMP}_{sp})$ (SAC - DESOPTS) (ones comp. difference)

TRTEMP = $(C_{trunsf} / \text{RATETEMP}_{sp})$ (PACTEMP - DESOPTT) (ones comp. diff.)

RATETEMP+1 = 1 (B14, counter)

If$(|\text{SRTEMP}| + K_{mmaxsrt}) > 0$:

SRTEMP = $- K_{mmaxsrt}$ sgn SRTEMP

RATETEMP+1 = 0

If$(|\text{TRTEMP}| + K_{mmaxsrt}) > 0$:

TRTEMP = $- K_{mmaxsrt}$ sgn TRTEMP

(TRATE, SRATE) = (TRTEMP, SRTEMP)

Proceed to "R53CHK"

ADVTRACK Entered from "R52D" for advanced ground track (specified via "S22N7071")

$\underline{TS}_1$ = unit$\underline{Z}$

$TS_2 = T_{now}$

AOPTIME = TS_2

TS = TS_2 (non-zero, meaning moon)

Perform "RP-TO-R"

STA$\underline{R}$ = T$\underline{S}$

T_{decl} = AOPTIME

Perform "CSMCONIC"

$\underline{TS}_1 = (\underline{V}_{att} * \underline{R}_{att})$ (in push-down address 24D)

PDULO$\underline{S}$ = - unit$\underline{R}_{att}$

TS = (bits 3-1 of LANDMARK), rescaled to scale factor B4

AOPANG = $K_{mperiod}$ TS

$\underline{TS}_2$ = (STA$\underline{R}$ · PDULO$\underline{S}$) STA$\underline{R}$

PDULO$\underline{S}$ = unit$\Big($(PDULO$\underline{S}$ - $\underline{TS}_2$) cos AOPANG + $\underline{TS}_2$ +
(STA$\underline{R}$ * PDULO$\underline{S}$) sin AOPANG$\Big)$

STA$\underline{R}$ = unit$\underline{TS}_1$

AOPANG = (1/6) - AOPANG (the 1/6 is 60°)

$\underline{TS}_2$ = (STA$\underline{R}$ · PDULO$\underline{S}$) STA$\underline{R}$

PDULO$\underline{S}$ = unit$\Big($(PDULO$\underline{S}$ - $\underline{TS}_2$) cos AOPANG + $\underline{TS}_2$ +
(STA$\underline{R}$ * PDULO$\underline{S}$) sin AOPANG$\Big)$

STA$\underline{R}$ = PDULO$\underline{S}$

T$\underline{S}$ = STA$\underline{R}$

Proceed to "COM52"

R53 Entered from "P23", "P51B", and "R53JOB"

R53EXIT = Return address

Set bit 6(SGTMK) of FLAGWRD0 = 1 (program notation R53FLAG)

Perform "SXTMARK"

If MODREG $\neq$ 24:

TS = 4

If MODREG = 22:

TS = 0

If (TS - 5 + MARKINDX) = 0: (i.e. no marks made)

Proceed to third line of "R53"

Perform "MKRELEAS" (Tag here "R53A1")

Proceed to "R53C1"

R53C1 Entered from "R53" and "R56"

TS = 0

Perform "CLEANDSP"

If (MODREG - 32) $\leq$ 0: (e.g. P22, P23, or P24)

Set bit 15(TERMIFLG) of FLAGWRD7 = 1

Proceed to address specified by R53EXIT

TS = 0171_{vn} (Tag here "R53C")

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

If STARCODE $\leq$ -0 or if STARCODE > 50_8:

Set bit 7(Operator Error) of channel 11 = 1

Proceed to 6th line of "R53C1"

TS = 6 (bits 6-1 of STARCODE)

If STARIND = 0:

BESTI = TS

If STARIND = 1:

BESTJ = TS

Set bit 15(TERMIFLG) of FLAGWRD7 = 1 (no effect for R56)

Proceed to address specified by R53EXIT

R56 Entered from "P51B" and "R51"

R53EXIT = Return address

TS = 0694_{vn}

Proceed to "VNFLASH": (if terminate, proceed to "GOTOPOOH")
if proceed, proceed
otherwise, proceed to previous line

Perform "TESTMARK" (Tag here "R56A")

TS = 0

Perform "CLEANDSP"

TS = 5300_{vn}

Proceed to "GOMARK2": if terminate, proceed to "GOTOPOOH"
if proceed, proceed to previous line
otherwise, proceed

SAC = MRKBUF1+3 (loaded in R1 of N94)

PAC = MRKBUF1+5 (loaded in R2 of N94)

Inhibit interrupts (SAC and PAC loading done in interpretive language, maximizing the delay between ENTR response and the sampling of CDU angles. Also can be delayed if R67 active, since higher priority than P54/R56).

$MRKBUF1_{dp} = T_{now}$

MRKBUF1+2 = CDU_y

MRKBUF1+4 = CDU_z

MRKBUF1+6 = CDU_x

Release interrupts

Perform "CLEARMRK"

TS = 00016_8

Proceed to "GOPERF1": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to 4th line of "R56"

Proceed to "R53C1"

R57 Entered from "P23" and "R57D"

If bit 13(REFSMFLG) of FLAGWRD3 = 1:

TS = 00015_8

Proceed to "GOPERF1": if terminate, proceed to "GOTOPOOH"
if proceed, proceed
otherwise, proceed to "R57C"

Perform "R51DSPA"

Perform "DOR60" (TS set from "R51DSPA")

Proceed to "R57C"

R57C

Perform "TESTMARK"

Set bit 12(P23CALIB) of FLAGWRD5 = 1

TS = 5900_{vn}

Perform "GOMARKFR": if terminate, proceed to "GOTOPOOH"
if proceed, skip next 2 lines
otherwise, skip next 2 lines

TS = 111_2 and perform "BLANKET" (R3BLNK, R2BLNK, R1BLNK)

End of job

Proceed to "ENDR57"

MARKDISP Established by "MARKDIF"

TS = 0687_{vn} (see "OPDEGOUT": a negative "true" angle is 90-θ)

Perform "GOMARKFR": if terminate, proceed to "GOTOPOOH"
if proceed, skip next 2 lines
otherwise, proceed to "R57D"

TS = 101_2 and perform "BLANKET" (R3BLNK, R1BLNK)

End of job (can use V22 N 94E to change MRKBUF1+5)

TRUNBIAS = MRKBUF1+5 - $K_{19p77deg}$ (ones complement difference of twos complement numbers formed)

Proceed to "ENDR57"

R57D

Perform "CLEARMRK" (if merely want to repeat mark, need just push mark button again)

Proceed to "R57"

ENDR57

Set bit 12(P23CALIB) of FLAGWRD5 = 0

Perform "CLEARMRK"

Return (to routine calling "R57")

Quantities in Computations

See also list of major variables and list of routines

ALPHA$\underline{V}$: See Coordinate Transformations.

ALT: See Coordinate Transformations.

AOPANG: Rotation angle used in "ADVTRACK", scale factor B0, units revolutions. Uses same cell as AOPTIME, but separate tag used for clarity.

AOPOLD: Previous value of AOPTIME used in "RATESUB" to compute optics rates, scale factor B28, units centi-seconds.

AOPTIME: Value of R52 time used to compute optics pointing information for landmark or LM, scale factor B28, units centi-seconds. Except for use in advanced ground track mode, incremented in "R52D" in order to compensate for computing and optics hardware delays.

BESTI, BESTJ: See Inflight Alignment.

$C_{cduchkwd}$: Single precision erasable memory constant, program notation "CDUCHKWD", scale factor B14, used to specify (if positive non-zero) the number of centi-seconds delay before "MARKDIF" is performed after receiving an optics mark button input. If the cell is zero or negative, the delay is 0.01 second.

C_{nopass}: Single precision erasable memory constant, program notation "NO.PASS", scale factor B14, used to specify how often a check should be made in "R52C" for a new mark from which to compute a revised landmark location. To check every $\underline{n}$th time, cell should be set to $\underline{n}$, since except for "PROG24" initial setting the loading of PASSCNT is done with the decremented value of the constant.

$C_{shaftsf}$: Single precision erasable memory constant, program notation "SHAFTSF", scale factor B25, units pulses per (revolution/centi-second). For a saturated error counter (384 pulses) corresponding to N degrees/second, cell should be set to 384 x 360 x (1/N) x 100 x 2^{-25}, where first term is saturated error counter (600_8), second converts from revolutions to degrees, third is reciprocal of full-scale error counter, fourth converts from seconds to centi-seconds, and fifth is scale factor. For 20^o/second (approximate value in an earlier design), this formula gave 337.5 x 2^{-14}.

C_{trunsf}: Single precision erasable memory constant, program notation "TRUNSF", scale factor B27, units pulses per (revolution/centi-second). For a saturated error counter corresponding to M degrees/second, cell should be set to 384 x 360 x (1/M) x 100 x 2^{-27}, where terms have analogous meanings to those for $C_{shaftsf}$. For 10^o/second (approximate value in an earlier design), this formula gave $\frac{1}{2}$ (337.5 x 2^{-14}).

C31FLWRD: See Digital Autopilot RCS Routines.

CDUS: Single precision value of counter input cell 0036_8, containing the optics CDU shaft angle (also identified with the X axis), scale factor B-1, units revolutions, in twos complement.

CDUT: Single precision value of counter input cell 0035_8, containing the optics CDU trunnion angle (also identified with the Y axis), scale factor B-3, units revolutions, in twos complement. See K_{20degs}.

CDUiCMD (i = T, S): Single precision value of computer special erasable memory cells 0053_8 - 0054_8 respectively (also identified as OPTYCMD and OPTXCMD respectively). Pulses are generated based on the contents of these cells if bits 12-11 respectively of channel 14 = 1, and the optics CDU error counter is loaded from the 3200 pps pulse train information if bit 2 of channel 12 = 1. For the position-command mode (bit 8 of channel 12 = 0), 2^{15} pulses from CDUTCMD, and 2^{13} pulses from CDUSCMD, give one revolution. For the rate-command optics mode (bit 8 of channel 12 = 1), a saturated error counter (384 pulses) is e.g. 10°/sec for CDUTCMD and 20°/sec for CDUSCMD. The same cells (in this "rate" mode, i.e. with error counter giving a steady voltage level output) are also used for TVCYAW and TVCPITCH commands for the SPS engine (see Digital Autopilot Interface Routines).

COMMANDT, COMMANDS: Raw values of trunnion and shaft commands computed in "OPTTEST" for optics position-command mode, same scaling as CDUiCMD. The sign of COMMANDS may be reversed for shaft-stop avoidance purposes.

CSMPO$\underline{S}$:See Measurement Incorporation.

DESOPMOD: Single precision value of SWSAMPLE the previous time that "OPTMON" was performed, used to determine if a change has taken place in the setting of the optics mode switches (Computer Control, Manual, or Zero).

DESOPTT, DESOPTS: Single precision values of desired CDUT and CDUS respectively, twos complement with same scaling as CDUT and CDUS respectively. They are used in "OPTTEST" to generate optics driving commands (if OPTIND and SWSAMPLE are satisfactory), and in "RATESUB" as the previous cycle's desired value for use in generating optics rate command information.

ERADM: See Coordinate Transformations.

EXTVBACT: See Verb Definitions.

IMODES33: See IMU Computations.

$K_{2p4secdp}$: Constant, program notation "2.4SECDP", scale factor B28, units centi-seconds. Value is 240 x 2^{-28}, corresponding to 2.4 seconds.

$K_{19p77deg}$: Single precision constant, program notation "19.77DEG", scale factor B-3, units revolutions. Value is 61740_8, corresponding to -7199 x 2^{-14} (ones complement), but since is used (in "MARKDISP") in twos complement, is equivalent to -7200 x 2^{-14}, or 19.7754° (added to raw optics trunnion angle to compute bias). See K_{20degs}.

K_{20degs}: Single precision constant, program notation "20DEGS", scale factor B-3, units revolutions. Value is 7199 x 2^{-14}, but since used (in "ENDZOPT") in complement form, value equivalent to 7200 x 2^{-14}, or 19.7754°. When the optics are "zeroed", the CDUT cell is loaded with - K_{20degs}: consequently, to find the "true" trunnion angle, this 19.7754° value must be added, and to convert "true" to actual cell contents this 19.7754° value must be subtracted. See e.g. "CALCSXA". Octal is 61740_8 (set).

$K_{20dgsmn}$: Constant, program notation "20DEGSMN", scale factor B-3, units revolutions. Value is -7199 x 2^{-14} (as a ones complement number), equivalent to -19.7754° (see K_{20degs}). Causes limiting of trunnion value if the derived "true" angle is negative.

K_{45dg}: Single precision constant, program notation "13,14,15", scale factor B-1, units revolutions. Value is 70000_8, corresponding to a value of 10000_8 as used in program (after a one-bit correction for convenience in forming absolute value), or 45°. If CDUS is = or less than this value, then ZONE is set 0; if greater and ZONE is zero, then ZONE is set to CDUS.

K_{50dgtr}: Constant, program notation "38TRDEG", scale factor B-3, units revolutions. Value is 0.66666667, corresponding to 30° in the value of CDUT, or a "true" trunnion angle of 30 + 19.7754 = 49.7754° (see K_{20degs}). Constant formerly was 0.4 (a "true" value of 37.7754°), hence the notation.

K_{90dg}: Single precision constant, program notation "NEG1/2", scale factor B-1, units revolutions. Value is 57777_8, corresponding to a value of 20001_8 as used in the program (after a one-bit correction for convenience in forming absolute value), or about 90°. If CDUS magnitude is less than 90°, then there is considered to be no problem with the optics stops.

K_{m3bt}: Single precision constant, program notation "NEG2", scale factor B-1, units revolutions. Value is -2 x 2^{-14}, but used in program in such a way (for convenience in forming absolute value) that effective value in program is -3, or about -0.033°. A change in an IMU CDU angle of more than 3 least increments in $C_{cduchkwd}$ centi-seconds causes the optics mark to be rejected in "MARKDIF", except for P24.

$K_{mmaxsrt}$: Single precision constant, program notation "-MAXSRT", scale factor B14, units pulses. Value is -384 x 2^{-14}, corresponding to -384 (the complement of the value of a saturated error counter, which is 600_8 = 384).

$K_{mperiod}$: Constant, program notation "MPERIOD", scale factor B-4, units revolutions (of moon) per orbit (of CSM). Value is 0.047619. For a lunar rotation rate of 2.66169947E-6 rad/sec (see $K_{omegmoon}$ in Orbital Integration), this would be an orbit period of about 117.1 minutes. This time is the period of a circular orbit about 50 nmi above the mean lunar radius.

K_{mxps}: Single precision constant, program notation "MAXPLS", scale factor B14, units optics CDU output pulses. Value is -83×2^{-14}. See CDUiCMD above for pulses/revolution, noting that a scale factor for single precision information of B1 revolutions is equivalent to a scale factor of B14 pulses if 2^{13} pulses = 1 revolution.

K_{mxps1}: Single precision constant, program notation "MAXPLS1", scale factor B14, units optics CDU output pulses. Value is -82×2^{-14}, but used in program (for convenience in forming absolute value) in such a way that effective value is -83 (see K_{mxps}).

$K_{p5secdp}$: Constant, program notation ".5SECDP", scale factor B28, units centi-seconds. Value is 50×2^{-28}, corresponding to 0.5 seconds.

LANDALT, LANDLONG: See Orbital and Rendezvous Navigation.

LANDMARK: See Orbital and Rendezvous Navigation.

MARKDATA: See Measurement Incorporation.

MARKDOWN: See Measurement Incorporation.

MARKINDX: Single precision cell, scale factor B14, loaded in "SXTMARK" with 5 for P22/P24, and with 1 for other programs, and modified in "MARKDIF" so as to contain the count of the number of marks remaining (except for P24, when returned to original value). It is incremented in "MKREJCT" (except P24) when a mark is rejected. Used in "R53" (except for P24) to force at least one mark to be processed before termination of the mark sequence.

MKCDUi, MKT2T1: Set of buffer cells loaded in "MARKRUPT" with optics and IMU CDU angles (with time in MKT2T1, double precision), and used in "MARKDIF" to load appropriate cells. The sequence of the cells in memory is $MKT2T1_{dp}$, MKCDUY, MKCDUS, MKCDUZ, MKCDUT, and MKCDUX.

MRKBUF1: Set of cells loaded in "PUTMARK" with optics mark information for those programs not using the SVMRKDAT set (i.e. except for P22 and P24). Sequence of cells has data as described above for MKCDUi, MKT2T1. For common use of processing routines, "R23CSM1" and "R56" load these cells with information in the same format as that done for normal optics marks. For R22 use, a setting of MRKBUF1 to a negative number indicates that no mark data are in the cells. In that program, a mark reject (or V86E) must be done sufficiently promptly after a mark to avoid having it be incorporated (barring the N49 display). The notation "MRKBUF1" refers to the first cell of the set, i.e. MRKBUF1+0 (there are 7 cells in the set).

NUM8NN: See Orbital and Rendezvous Navigation.

OPTCADR: Single precision cell used to contain return address for "SXTMARK".

OPTIND: Single precision control cell, scale factor B14, used to control the performance of "OPTTEST". If it is negative, including -0, driving of the optics is bypassed. A setting of -0 means that the optics are "reserved": this setting is done in "S40.6" when the output channel bits are set for TVC use (see CDUiCMD above). The setting to -1 is done in e.g. "INITSUBA" in conjunction with V37 processing.

OPTMODES: Single precision flag word used for control of "T4RUPT" computations associated with the optics hardware. The individual bits have the following meanings:

Bit	Symbol	Meaning
10	ZROPTFIN	Zeroing of optics has been completed since last fresh start or restart if bit is 1.
7	OCDUFBIT	Nominal last sampled value of channel 30 bit 7 (0 if an optics CDU fail indication has been generated by the optics CDU hardware). If OPTIND = -0, the value of the bit is not changed in "OPTMON", although a channel 30 bit 7 change will cause "OCDUFTST" to be entered to change bit 8 of DSPTAB+11 (the Tracker light).
5	OPMD1BIT	Last sampled value of channel 33 (or C31FLWRD) bit 5: zero if Computer Control mode of optics desired.
4	OPMD2BIT	Last sampled value of channel 33 (or C31FLWRD) bit 4: zero if Zero Optics mode of optics desired. If bits 5-4 = 11_2, Manual mode of optics desired.
3	ZOPTCS	Bit set 1 in "CSCTOZOP" to indicate that the wait for zeroing of optics is in process. It is set zero in "ENDZOPT", after the completion of the necessary wait.
2	OCDUINHT	Bit set 1 to inhibit generation of Tracker alarm (bit 8 of DSPTAB+11) within "OCDUFTST" routine.

P22DEX: Single precision cell, scale factor B14, used to select the appropriate set of SVMRKDAT cells to be loaded in "MARKDIF" for P22 and P24: it equals the first cell of the SVMRKDAT set which is to be loaded when the next mark is received (decremented by 7 for a P22 mark reject).

PAC: See Coordinate Transformations.

PACTEMP: Single precision cell, same scaling as PAC, used to retain the value of PAC derived in R52, with limiting if necessary, that is subsequently loaded into DESOPTT.

PASSCNT: Single precision counter, scale factor B14, initialized using C_{nopass} in "PROG24" and used in "R52C" to determine if a check should be made for a P24 mark upon which a revised landmark location computation should be based.

PDULOS: Value of unit line-of-sight information used in "ADVTRACK", scale factor B1, stored in push-down list location OD.

R53EXIT: Single precision cell containing return address from "R53" or "R56" (allowing "R53C1" to be used by both).

RATETEMP: Pair of cells used in "RATESUB" for temporary storage purposes. Detail shown there since same cells used for (VHFCNT, TRKMKCNT). See Measurement Incorporation.

S22RHO: See Orbital and Rendezvous Navigation.

S22TOFF: See Orbital and Rendezvous Navigation.

SAC: See Coordinate Transformations.

SAVQR52: Single precision cell containing return address from "R52".

SOLD: Value of present shaft-driving error counter used for the rate mode of the optics, scale factor B14, units pulses. Cell required because error counter driven from CDUSCMD cell to change value, but SRATE contains the desired value itself. SOLD zeroed in e.g. "CSCTOMAN", where zeroing of bit 2 of channel 12 also zeros the error counter.

SRATE: Value of desired shaft rate, scale factor B14, units pulses (see $C_{shaftsf}$). The cell is set 0 in "OPTTEST" if necessary to avoid the shaft stop.

SRTEMP: Temporary storage for new shaft rate derived in "RATESUB", to avoid changing SRATE cell prior to limiting and to allow both SRATE and TRATE to be changed effective with the same optics interrupt.

STAR: See Coordinate Transformations. Used in "R52D" to retain temporarily the position vector of LM or landmark (scale factor B29, units meters). In "ADVTRACK" it is used to retain the unit vectors, scale factor B1, about which rotation is performed.

STARCODE: See Inflight Alignment.

STARIND: See Inflight Alignment. Set 0 in "R00" so that "R52D" will select STARSAV2 for e.g. P23.

STARSAV1, STARSAV2: See Inflight Alignment.

SVMRKDAT: See Orbital and Rendezvous Navigation.

SWSAMPLE: Single precision cell containing information on the value of the optics hardware mode last sampled in "OPTMON" (DESOPMOD is loaded with the same value before termination of the routine). A positive non-zero value (i.e. 15) means Computer Control mode; a zero value means Manual mode; and a negative value (-1) means Zero Optics mode. Scale factor is B14.

T_{st}: See Data Input/Output.

TOLD: Value of present trunnion-driving error counter used for the rate mode of the optics, scale factor B14, units pulses (see SOLD).

TRATE: Value of desired optics trunnion rate, scale factor B14, units pulses (see C_{trunsf}).

TRTEMP: Temporary storage for new trunnion rate derived in "RATESUB" (see SRTEMP).

TRUNBIAS: Single precision value of trunnion bias angle, scale factor B-3, units revolutions, computed in "MARKDISP" (in R57) for use in "P23.85" (part of P23). Nominal "true" trunnion angle for the R57 procedure is zero (hence $K_{19p77deg}$ is subtracted from the observed angle cell contents given by MRKBUF1+3).

U$\underline{M}$: See Measurement Incorporation.

WTOPTION: Single precision cell, scale factor B14, set to 11 in "OPTMON" if switch from Zero to Manual optics mode with zeroing not yet complete (alarm 0116_8 is generated also). It is decremented by 1, with a lower limit of +0, when "OPTMON" is entered with previous and present cycle modes both Manual. If switch back to Zero from Manual before counter decremented to 0 (which occurs in about 5.3 seconds), then ZOPTCNT is not reset to 32. Cell set 0 in "CSCTOZOP" and in "OPTMON" if go from Zero to Computer Control.

X78$\underline{9}$: See Measurement Incorporation (no "measurement incorporation routines" of the P22 type used for P24, of course).

ZONE: Single precision cell set 0 in "ENDZOPT" or in "OPTTEST" if CDUS magnitude less than 45°, and set in "OPTTEST" if CDUS magnitude exceeds 45° and cell presently 0. It is used in "OPTTEST" in the implementation of the optics shaft stop monitor (if non-zero, only its sign is employed). Cell is required because optics shaft stops are at ± 270° from "zero" ("zero" is the position at which optics are left after zero mode employed). If, after zeroing, were to drive optics towards e.g. +70°, then when CDUS exceeded 45° ZONE would be set to positive non-zero. If continued to drive in the same direction, e.g. to +100°, then +140°, then +170° (always with increments of less than 180° from present CDUS, so go "shortest" way, namely in same direction), then ZONE would remain positive non-zero and optics would continue to drive. If, from the 170° point, the next DESOPTS were -160° (or, equivalently, +200°), then "shortest distance" would again be the 30° across the 180° point, and the optics would be driven there, with ZONE remaining untouched (CDUS reading would be "-160°"

when reach DESOPTS). Note that, however, if had started at the "zero" point, would have driven optics in the opposite direction (i.e. though -30, -70, etc.). If the next DESOPTS were e.g. -100^{o}(i.e. $+260^{o}$), then here the optics would again be driven in the same direction, with ZONE unchanged, from -160^{o} to -100^{o}, or only 10^{o} away from the stop at $+270^{o}$ (note that "normal" method of reaching -100^{o}, from "zero", would have gone the other way). At the -100^{o} (actually $+260^{o}$ as far as how shaft angle got there is concerned) point, ZONE is still positive non-zero. If the next DESOPTS were e.g. -60^{o} (i.e. $+300^{o}$), this would generate a COMMANDS of $(-60^{o}) - (-100^{o}) = +40^{o}$: to drive there directly, however, would require violating the hardware stop at 270^{o}, and hence the stop monitor logic is invoked. With these conditions, all the conditions at the top of page OPTC-2 are satisfied, since CDUS magnitude (100^{o}) exceeds 90^{o}; ZONE $\neq 0$; the sign of ZONE = sign of COMMANDS (both positive); and magnitude of DESOPTS is 60^{o} (less than 90^{o}). Consequently, the COMMANDS polarity is reversed, so that instead of driving towards -60^{o}, the optics are driven towards -140^{o} (-100 + -40). Assuming that DESOPTS remains -60^{o}, the next attempt would be to drive towards -220^{o} ($+140^{o}$, i.e. -140 -(-60 --140)), and so on. When CDUS is driven below 90^{o}, then shaft stop logic is no longer involved, since "shortest path" is likewise one that avoids the optics shaft stops. Finally, when optics reaches the -60^{o} point (the "long way"), ZONE would have been reset to 0 and then to negative non-zero, to protect the stop at -270^{o} ($+90^{o}$). If the value of DESOPTS were to "chatter" near a magnitude of 270, then the optics themselves would be driven in alternating directions: in this case, manual selection of optics zeroing should be done.

ZOPTCNT: Single precision cell, scale factor B14, set to 32 at the start of optics zeroing (assuming no WTOPTION effect), to give an optics zeroing period of $33 \times 0.48 + 0.4 \cong 16.2$ seconds. An alarm (pattern 116_8) is generated if switch out of zeroing before completion of initial part of delay (about 15.8 seconds from when switch first sensed to be in zero mode). See WTOPTION (no setting of WTOPTION is made if switch to Computer Control: it is reset to 0 instead).

STATEINT Called by "ENDINT", and restarted via group 2.3

Establish "STATINT1" (priority 05_8)

End of task

STATINT1 Established by "NDUTINPT" if bit 9(UTFLAG) of FLAGWRD8 = 1, by "STATEINT", and by restart group 2.5 (in "R00" for P00)

If bit 5(QUITFLAG) of FLAGWRD9 = 1: (set by "VERB96")

Make restart group 2 inactive

Set bit 5(QUITFLAG) of FLAGWRD9 = 0

End of job (must key e.g. V37E00E to get periodic integration)

$T_{decl} = T_{now}$

Set bit 3(V96ONFLG) of FLAGWRD8 = 0

Perform "INTSTALL"

Set bit 1(NODOV37) of FLAGWRD2 = 1

Set bit 5(STATEFLG) of FLAGWRD3 = 1

Set bits 4(CONICINT), 2(9DIMWMAT), and 1(WMATINT) of FLAGWRD3 = 0

Set bit 9(P00FLAG) of FLAGWRD3 = 1

Set bit 3(CSMINTSW) of FLAGWRD3 = 1 (Tag here "STATEUP")

If bit 6(ORBWFLAG) of FLAGWRD3 = 1:

Set bit 1(WMATINT) of FLAGWRD3 = 1

Set bit 8(PRECIFLG) of FLAGWRD3 = 0

Perform "INTEGRV"

If bit 8(SURFFLAG) of FLAGWRD8 = 1:

Set bit 1(NODOV37) of FLAGWRD2 = 0

Proceed to "ENDINT"

$T_{decl} = T_{etcm}$

Perform "INTSTALL"

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Set bit 5(STATEFLG) of FLAGWRD3 = 1

Set bits 4(CONICINT), 2(9DIMWMAT), and 1(WMATINT) of FLAGWRD3 = 0

If bit 1(RENDWFLG) of FLAGWRD5 = 1:

Set bit 1(WMATINT) of FLAGWRD3 = 1

Set bit 8(PRECIFLG) of FLAGWRD3 = 1

Perform "INTEGRV"

Set bit 1(NODOV37) of FLAGWRD2 = 0

Proceed to "ENDINT"

ENDINT

Set bit 5(STATEFLG) of FLAGWRD3 = 0

Set restart group 2 to phase 3 (2.3, causing "STATEINT" to be called)

Call "STATEINT" in K_{600sc} seconds

End of job

CSMPREC

Perform "INTSTALL"

IRETURN = Return address (to routine calling "CSMPREC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

Set bit 8(PRECIFLG) of FLAGWRD3 = 1

Set bits 4(CONICINT) and 1(WMATINT) of FLAGWRD3 = 0

Proceed to second line of "INTEGRV"

LEMPREC

Perform "INTSTALL"

IRETURN = Return address (to routine calling "LEMPREC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Proceed to 4th line of "CSMPREC"

CSMCONIC

Perform "INTSTALL"

IRETURN = Return address (to routine calling "CSMCONIC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

Set bit 1(WMATINT) of FLAGWRD3 = 0

Set bit 4(CONICINT) of FLAGWRD3 = 1

Proceed to second line of "INTEGRV"

<u>LEMCONIC</u>

Perform "INTSTALL"

IRETURN = Return address (to routine calling "LEMCONIC")

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Proceed to 4th line of "CSMCONIC"

<u>INTEGRVS</u>

Set bit 8(PRECIFLG) of FLAGWRD3 = 1

PBODY = 0

If bit 12(MOONFLAG) of FLAGWRD0 = 1:

PBODY = 2

IRETURN = Return address (to routine calling "INTEGRVS")

TDELTA$\underline{V}$ = 0

TNU$\underline{V}$ = 0

Perform "RECTIFY"

Set bit 1(WMATINT) of FLAGWRD3 = 0

Set bit 15(RPQFLAG) and 13(NEWIFLG) of FLAGWRD8 = 1

Proceed to "ALOADED"

<u>INTSTALL</u>

QPRET = Return address (since enter in interpretive language)

If bits 14(INTINUSE) and 13(INTGRAB) of FLGWRD10 $\neq 00_2$:

Put present job to sleep (starting address id = 2nd line of "INTSTALL", i.e. check of bits)

Set bit 14(INTINUSE) of FLGWRD10 = 1

Proceed to address specified by QPRET (of present job, of course)

INTWAKE

If bit 13(INTGRAB) of FLGWRD10 = 1: (means restarted)

TBASE2 = QPRET of present job

Set restart group 2 to resume computations at next step

QPRET (of present job) = TBASE2

If bit 13(INTGRAB) of FLGWRD10 = 0: (i.e. got a restart)

Proceed to address specified by QPRET (of present job)

Awaken all jobs with starting address id = 2nd line of "INTSTALL" (Tag here "INTWAKEO")

Set bits 14(INTINUSE) and 13(INTGRAB) of FLGWRD10 = 0

Proceed to address specified by QPRET (of present job)

AVETOMID (Entered from "AVGEND")

EGRESS = Return address

If bit 1(RENDWFLG) of FLAGWRD5 and bit 6(ORBWFLAG) of FLAGWRD3 $\neq 00_2$:

$TS_1 = T_{pptm}$ (holds in MPAC) (tag here "INT/W")

Perform "INTSTALL"

Set bit 1(WMATINT) of FLAGWRD3 = 1

Set bit 1(AVEMIDSW) of FLAGWRD9 = 1

Set bit 2(9DIMWMAT) of FLAGWRD3 = 0

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

$T_{decl} = TS_1$

Perform "INTEGRV"

X2 = 2 (flag for moon scaling) (tag here "SETCOAST")

Perform "INTSTALL"

If bit 2(AMOONFLG) of FLAGWRDO = 0:

X2 = 0

$\underline{R}_{rect} = \underline{R}$ (shifted left X2 places)

$RC\underline{V} = \underline{R}_{rect}$

$T_{et} = T_{pptm}$

$\underline{V}_{rect} = \underline{V}$ (shifted left X2 places)

VC$\underline{V}$ = $\underline{V}_{rect}$

TDELTA$\underline{V}$ = 0

TNU$\underline{V}$ = 0

$T_c = 0$

XKEP = 0 (notation also "XPREV")

Perform "MOVEACSM"

Set bit 12(CMOONFLG) of FLAGWRD8 = 1

If bit 2(AMOONFLG) of FLAGWRD0 = 0:

 Set bit 12(CMOONFLG) of FLAGWRD8 = 0

If bit 8(SURFFLAG) of FLAGWRD8 = 1:

 QPRET = EGRESS

 Proceed to "INTWAKE" (will return to address in QPRET)

$T_{decl} = T_{pptm}$

Set bit 5(STATEFLG) of FLAGWRD3 = 1

Set bits 4(CONICINT), 2(9DIMWMAT), and 1(WMATINT) of FLAGWRD3 = 0

Set bit 3(CSMINTSW) of FLAGWRD3 = 0

Perform "INTEGRV"

Proceed to address specified by EGRESS

<u>MIDTOAV1</u> R41 entrance for a "reset TIG flag", from "P40S/SV" (P15, P40, and P41)

IRETURN1 = Return address

Perform "INTSTALL"

Set bit 3(MID1FLAG) of FLAGWRD9 = 1

$TS = T_{now} + K_{timedt}$

If $T_{decl} - TS < 0$: (i.e. desired time less than K_{timedt} from now)

 Set bit 3(MID1FLAG) of FLAGWRD9 = 0

 IRETURN1 = IRETURN1 +1

 Perform "ALARM" (pattern 1703_8)

 TTOADD = K_{timedt}

 Proceed to 5th line of "MIDTOAV2"

Proceed to 6th line of "MIDTOAV2"

MIDTOAV2 (R41 entrance for a "set TIG flag", from "P47CSM" and "S61.1")

IRETURN1 = Return address

Perform "INTSTALL"

Set bit 3(MID1FLAG) of FLAGWRD9 = 0

TTOADD = K_{timedt}

$T_{decl} = T_{now}$ + TTOADD (tag here "ENTMID2")

Set bit 1(WMATINT) of FLAGWRD3 = 0 (tag here "ENTMID1")

Set bit 3(CSMINTSW) of FLAGWRD3 = 1

Set bit 4(CONICINT) of FLAGWRD3 = 0

Set bit 2(MIDAVFLG) of FLAGWRD9 = 1 (causes "DIFEQ+2" to transfer to "CKMID2")

Perform "INTEGRV"

RTX2 = X2 (0 for earth, 2 for moon: used e.g. by "CALCGRAV")

RTX1 = X1 (-2 for earth, -10 for moon)

Set bit 2(AMOONFLG) of FLAGWRD0 = 0

If RTX2 $\neq$ 0:

Set bit 2(AMOONFLG) of FLAGWRD0 = 1

$\underline{R}_{n1} = \underline{R}_{att}$

$\underline{V}_{n1} = \underline{V}_{att}$

$T_{pptm1} = T_{att}$

Inhibit interrupts

TS = $T_{pptm1} - T_{now}$, with sign agreement forced

Proceed to address specified by IRETURN1

CKMID2 Entered from "DIFEQ+2" if bit 2 of FLAGWRD9 = 1

If bit 3(MID1FLAG) of FLAGWRD9 = 0:

If $|T_{dec} - T_{et}| - K_{3csecs} < 0$:

If $(T_{et} - T_{now} - K_{5p6secs}) \geq 0$, proceed to "A-PCHK"

TTOADD = TTOADD + K_{timedt}

$T_{dec} = T_{now}$ + TTOADD

Proceed to "TESTLOOP"

$TS = T_{now} + K_{timedt}$

If $T_{dec} - TS \geqslant 0$:

Proceed to "TESTLOOP"

Set bit 3(MID1FLAG) of FLAGWRD9 = 0

IRETURN1 = IRETURN1 + 1

Perform "ALARM" (pattern 1703_8)

$TTOADD = K_{timedt}$

$T_{dec} = T_{now} + TTOADD$

Proceed to "TESTLOOP"

MOVEACSM

$\underline{R}_{rectcm} = \underline{R}_{rect}$

$\underline{V}_{rectcm} = \underline{V}_{rect}$

$T_{etcm} = T_{et}$

$DELTA\underline{V}_{cm} = TDELTA\underline{V}$

$NU\underline{V}_{cm} = TNU\underline{V}$

$RC\underline{V}_{cm} = RC\underline{V}$

$VC\underline{V}_{cm} = VC\underline{V}$

$T_{ccm} = T_c$

$XKEP_{cm} = XKEP$ (notation also "XPREV")

Return

MOVEALEM

$\underline{R}_{rectlm} = \underline{R}_{rect}$

$\underline{V}_{rectlm} = \underline{V}_{rect}$

$T_{etlm} = T_{et}$

$DELTA\underline{V}_{lm} = TDELTA\underline{V}$

$NU\underline{V}_{lm} = TNU\underline{V}$

$RC\underline{V}_{lm} = RC\underline{V}$

$VC\underline{V}_{lm} = VC\underline{V}$

$T_{clm} = T_c$

$XKEP_{lm} = XKEP$ (notation also "XPREV")

Return

<u>MOVEPCSM</u>

$\underline{R}_{rect} = \underline{R}_{rectcm}$

$\underline{V}_{rect} = \underline{V}_{rectcm}$

$T_{et} = T_{etcm}$

$TDELTA\underline{V} = DELTA\underline{V}_{cm}$

$TNU\underline{V} = NU\underline{V}_{cm}$

$RC\underline{V} = RC\underline{V}_{cm}$

$VC\underline{V} = VC\underline{V}_{cm}$

$T_c = T_{ccm}$

$XKEP = XKEP_{cm}$ (XKEP notation also "XPREV")

Return

<u>MOVEPLEM</u>

$\underline{R}_{rect} = \underline{R}_{rectlm}$

$\underline{V}_{rect} = \underline{V}_{rectlm}$

$T_{et} = T_{etlm}$

$TDELTA\underline{V} = DELTA\underline{V}_{lm}$

$TNU\underline{V} = NU\underline{V}_{lm}$

$RC\underline{V} = RC\underline{V}_{lm}$

$VC\underline{V} = VC\underline{V}_{lm}$

$T_c = T_{clm}$

$XKEP = XKEP_{lm}$ (XKEP notation also "XPREV")

Return

RECTOUT

Perform "RECTIFY" (sets X2 to PBODY)

$\underline{R}_{att} = \underline{R}_{rect}$	(shifted right by X2 places)	Push-down list 0D-5D
$\underline{V}_{att} = \underline{V}_{rect}$	(shifted right by X2 places)	6D-11D
$T_{att} = T_{et}$		12D-13D
$\underline{R}_{att1} = \underline{R}_{rect}$	(no shift)	14D-19D
$\underline{V}_{att1} = \underline{V}_{rect}$	(no shift)	20D-25D
$MUpPp = K_{muer_{-X2}}$		26D-27D

X1 = -10

If bit 12(MOONFLAG) of FLAGWRD0 = 0:

X1 = -2

Proceed to "INTEXIT"

INTEXIT

Reset overflow indicator

Set bits 2(MIDAVFLG) and 1(AVEMIDSW) of FLAGWRD9 = 0

Set bits 5(STATEFLG) and 8(PRECIFLG) of FLAGWRD3 = 0

QPRET = IRETURN

Proceed to "INTWAKE" (returns to address in QPRET)

USEPIOS Entered to obtain LM state vector if bit 8(SURFFLAG) of FLAGWRD8 = 1, from "INTEGRV" (for "conic" or "precision")

$T\underline{S}_1 = RL\underline{S}$

$TS_2 = T_{decl}$

$T_{et} = T_{decl}$

TS = 0.625 (i.e. non-zero quantity)

Perform "RP-TO-R"

$RC\underline{V} = T\underline{S}$

$T\underline{S}_1 = unit\underline{Z}$

$TS_2 = T_{et}$

$TS = 0.625$ (i.e. non-zero quantity)

Set bit 12(MOONFLAG) of FLAGWRDO = 1

Perform "RP-TO-R"

$\underline{VCV} = K_{omegmoon} (\underline{TS} * \underline{RCV})$

$\underline{TDELTAV} = 0$

X2 = 2 (i.e. moon)

PBODY = 2

$\underline{TNUV} = 0$

Proceed to "A-PCHK"

<u>TESTLOOP</u>

If bit 5(QUITFLAG) of FLAGWRD9 = 1: (set by "VERB96"; reset by "STATINT1")

Set bit 5(STATEFLG) of FLAGWRD3 = 0

Proceed to "INTEXIT"

X2 = PBODY

Set bit 13(MIDFLAG) of FLAGWRDO = 0

If $|\underline{RCV}| - K_{rme_{-X2}} \geq 0$: ($|\underline{RCV}|$ in push-down address 10D)

Set bit 13(MIDFLAG) of FLAGWRDO = 1

$TS_1 = K_{p3d} \sqrt{|\underline{RCV}|^3 / K_{muer_{-X2}}}$ (scaled B28 in units of centi-seconds)

$TS_2 = TS_1$ shifted right 7 places (giving scale factor B35, or least increment of 128 centi-seconds, with low-order bits of TS_1 lost)

$TS_3 = TS_2$ shifted left 15 places (giving scale factor B20 centi-seconds)

If $K_{dt2mx} - TS_3 < 0$, or if overflow taken place:

$TS_3 = K_{dt2mx}$ (TS_3 in push-down list location 12D)

$TS = T_{dec} - T_{et}$, with sign agreement forced

TS = TS, shifted left 8 places (scale factor B20, units centi-sec)

If $|TS| - TS_3 \geqslant 0$, or if overflow has taken place:

$TS = TS_3 \operatorname{sgn} TS$

If $|TS| - K_{dt2mn} < 0$:

Proceed to "A-PCHK"

$DTd2 = \frac{1}{2} TS$ (accomplished by considering scaling of DTd2 B19, whereas TS is scaled B20)

If bit 9(POOFLAG) of FLAGWRD3 = 0, proceed to "TIMESTEP"

If bit 8(PRECIFLG) of FLAGWRD3 = 1, proceed to "TIMESTEP" (not CSM from "STATINT1")

If $TS - TS_3 < 0$, proceed to "A-PCHK" (equals case does <u>not</u> transfer)

If bit 13(NEWIFLG) of FLAGWRD8 = 0, proceed to "TIMESTEP"

Set bit 13(NEWIFLG) of FLAGWRD8 = 0 (if get here, came from "STATINT1")

$TS_4 = T_{dec} - T_{et}$ (scale factor B28, units centi-seconds)

If $TS_4 < 0$, proceed to "INTEXIT" (no backwards integration)

TS_5 = TS, shifted right 6 places (rounded shift, scale factor B26)

If $TS_4 - 4\, TS_5 < 0$, proceed to "INTEXIT" ("4" because of scaling)

Proceed to "TIMESTEP" (at least 4 time steps behind)

<u>RECTIFY</u>

X2 = PBODY

$\underline{R}_{rect} = RC\underline{V}$ + (TDELTA$\underline{V}$, shifted right 7 +X2 places)

$RC\underline{V} = \underline{R}_{rect}$

$\underline{V}_{rect} = VC\underline{V}$ + (TNU$\underline{V}$, shifted right 4 +X2 places)

$VC\underline{V} = \underline{V}_{rect}$

$TDELTA\underline{V} = 0$

$TNU\underline{V} = 0$

$T_c = 0$

XKEP = 0 (notation also "XPREV")

Return

TIMESTEP

If bit 13(MIDFLAG) of FLAGWRDO = 1:

Perform "CHKSWTCH"

If TS $<$ 0:

Perform "ORIGCHNG"

Proceed to "INTGRATE"

Proceed to "RECTEST"

CHKSWTCH Entered from "A-PCHK" and "TIMESTEP"

If bit 15(RPQFLAG) of FLAGWRD8 = 1: (means RPQ$\underline{V}$ not available)

$TS = T_{et}$

Perform "LUNPOS"

If bit 12(MOONFLAG) of FLAGWRDO = 1:

$T\underline{S} = - T\underline{S}$

$RPQ\underline{V} = T\underline{S}$

X2 = PBODY (tag here "RPQOK")

$T\underline{S} = RC\underline{V} +$ (TDELTA$\underline{V}$, shifted right 7 +X2 places)

If bit 12(MOONFLAG) of FLAGWRDO = 1:

$TS = |T\underline{S}|$, scaled B29

$TS = K_{rsphere} - TS$ (negative if outside sphere and moon-centered)

If bit 12(MOONFLAG) of FLAGWRDO = 0:

$TS = |T\underline{S} - RPQ\underline{V}| - K_{rsphere}$ (negative if inside sphere and earth-centered)

Return

ORIGCHNG

Perform "RECTIFY" (leaves X2 set with PBODY)

$T\underline{S} = RC\underline{V} - RPQ\underline{V}$ (RC$\underline{V}$ shifted right X2 places)

$\underline{R}_{rect} = T\underline{S}$, shifted left (2 -X2 places)

$RC\underline{V} = \underline{R}_{rect}$

$TS = T_{et}$

Perform "LUNVEL"

If bit 12(MOONFLAG) of FLAGWRDO = 1:

$\underline{TS} = - \underline{TS}$

$\underline{TS}_1 = VC\underline{V} - \underline{TS}$ (VC$\underline{V}$ shifted right X2 places)

$\underline{V}_{rect} = \underline{TS}_1$, shifted left (2 -X2 places)

$VC\underline{V} = \underline{V}_{rect}$

If bit 12(MOONFLAG) of FLAGWRDO = 1:

Set bit 12(MOONFLAG) of FLAGWRDO = 0

PBODY = 0

Return

Set bit 12(MOONFLAG) of FLAGWRDO = 1

PBODY = 2

Return

RECTEST

If $|TDELTA\underline{V}| - K_{3d4} \geq 0$, or if overflow taken place:

Perform "RECTIFY"

Proceed to "INTGRATE"

If $|TDELTA\underline{V}|/|RC\underline{V}| - K_{recrat} \geq 0$: ($|TDELTA\underline{V}|$ shifted right (7 +X2) places)

Perform "RECTIFY"

Proceed to "INTGRATE"

If $|TNU\underline{V}| - K_{3d4} \geq 0$, or if overflow has taken place:

Perform "RECTIFY"

Proceed to "INTGRATE"

(Note that sensing overflow resets overflow indicator in all cases)

Proceed to "INTGRATE"

INTGRATE

$Z\underline{V} = TNU\underline{V}$

$Y\underline{V} = TDELTA\underline{V}$

Set bit 14(JSWITCH) of FLAGWRDO = 0

DIFEQCNT = 0

ALPHA$\underline{V}$ = Y$\underline{V}$

H = 0

Proceed to "ACCOMP"

<u>ACCOMP</u>

X1 = PBODY

X2 = PBODY

F$\underline{V}$ = 0

BETA$\underline{V}$ = RC$\underline{V}$ + ALPHA$\underline{V}$ (ALPHA$\underline{V}$ shifted right (7 +X2) places)

If bit 1(WMATINT) of FLAGWRD3 = 1:

$\text{VECTA}\underline{\text{B}}_{\text{-DIFEQCNT}}$ = BETA$\underline{V}$

ALPHAM = |ALPHA$\underline{V}$|

ALPHA$\underline{V}$ = unitALPHA$\underline{V}$

Perform "GAMCOMP"

TS_5 = X1

ALPHA$\underline{V}$ = BETA$\underline{V}$

ALPHAM = BETAM

If bit 13(MIDFLAG) of FLAGWRDO = 0:

Proceed to "OBLATE"

TS = T_{et}

Perform "LSPOS"

X2 = 2

X1 = TS_5 (restoring contents)

If bit 12(MOONFLAG) of FLAGWRDO = 1:

T$\underline{S}$ = - T$\underline{S}$

X2 = 0 (note this is reverse of usual X2 relation to bit 12)

$\underline{BETAV} = T\underline{S}$

$\underline{RPQV} = T\underline{S}$

$\underline{RPSV} = T\underline{S}_1$ (from push-down list address 2D)

If bit 1(WMATINT) of FLAGWRD3 = 1:

$VECTA\underline{B}_{6\text{-DIFEQCNT}} = \text{ALPHAM } \underline{\text{ALPHAV}} - \underline{\text{BETAV}}$ (first term shifted right 2 -X2 places)

X1 = X1 +4

Set bit 15(RPQFLAG) of FLAGWRD8 = 0

If bit 12(MOONFLAG) of FLAGWRDO = 1: (convert sun's vector to be with respect to moon)

$\underline{RPSV} = \underline{RPSV} + (\underline{RPQV}$, shifted right 9 places)

Perform "GAMCOMP" ($\underline{BETAV}$ set above to $\underline{RPQV}$)

X2 = 4 (selects mu of sun)

X1 = X1 +4

$\underline{BETAV} = \underline{RPSV}$

Perform "GAMCOMP"

Proceed to "OBLATE"

GAMCOMP

$\text{BETAM} = |\underline{\text{BETAV}}|$

$\underline{\text{BETAV}} = \text{unit}\underline{\text{BETAV}}$

RHO = ALPHAM / BETAM computed in quasi-floating point fashion, using $K_{\text{ascale}_{-X1}}$ for scaling information

$\text{LIILQ} = \text{RHO}\ (\text{RHO} - 2\ \underline{\text{ALPHAV}} \cdot \underline{\text{BETAV}})$ (same as $(\underline{A} - 2\ \underline{B}) \cdot \underline{A}/\underline{B}^2$ for non-unit vectors)

$$\text{FOFQ} = \text{LIILQ}\ \frac{3 + 3\ \text{LIILQ} + \text{LIILQ}^2}{1 + (1 + \text{LIILQ})^{3/2}}$$

$T\underline{S} = \underline{\text{ALPHAV}} + (\text{FOFQ/RHO})\ \underline{\text{BETAV}}$ (scaled B4)

$$T\underline{S}_1 = - K_{\text{muer}_{-X2}} \frac{\text{RHO}}{\text{BETAM}^2\ (1 + \text{LIILQ})^{3/2}}\ T\underline{S}$$ (computed quasi-floating point)

Reset overflow indicator

$\underline{FV} = \underline{FV} + T\underline{S}_1$ (using $K_{ascale_{-X1}}$ and $K_{ascale_{1-X1}}$ for scaling data)

If overflow has taken place, proceed to "GOBAQUE"

Return

<u>GOBAQUE</u> Entered if overflow from "DIFEQ+2","GAMCOMP", and "OBLATE"

If $|TDELTA\underline{V}| = 0$: (all components below 2 meters (earth) or 2^{-3} meters (moon))

Proceed to "POODOO" (pattern 20430_8)

$TAUORB = T_c - H$

$T_{et} = T_{et} - H$

Perform "KEPPREP"

Perform "RECTIFY"

Set bit 15(RPQFLAG) of FLAGWRD8 = 1

Proceed to "TESTLOOP"

<u>OBLATE</u>

X2 = PBODY

If $ALPHAM - K_{rde_{-X2}} \geq 0$, proceed to "NBRANCH"

If bit 12(MOONFLAG) of FLAGWRDO = 0:

$COSPHI = ALPHAV_z$ (ALPHA$\underline{V}$ here is a unit vector)

$U\underline{Z} = unit\underline{Z}$

If bit 12(MOONFLAG) of FLAGWRDO = 1:

$T\underline{S}_1 = ALPHA\underline{V}$

$TS_2 = T_{et}$

TS = 0.15 (i.e. non-zero quantity)

Perform "R-TO-RP"

$URP\underline{V} = T\underline{S}$

$T\underline{S} = (- unit\underline{Z} * \underline{C}_{5041m} + unit\underline{Z}) [MMATRIX]$

$U\underline{X} = (- unit\underline{X} * \underline{C}_{5041m} + unit\underline{X}) [MMATRIX]$

$U\underline{Z} = T\underline{S}$

$COSPHI = URPV_z$

$P_2' = 3$ COSPHI

$P_3' = \frac{1}{2}(15 \text{ COSPHI}^2 - 3)$

$P_4' = (1/3)(7 P_3' \text{ COSPHI} - 4 P_2')$

$P_5' = \frac{1}{4}(9 P_4' \text{ COSPHI} - 5 P_3')$

$$TS = \left(P_3' + \frac{K_{j3j2\_X2}}{\text{ALPHAM}}\left(P_4' + \frac{K_{j4j3\_X2}}{\text{ALPHAM}} P_5'\right)\right) \text{ALPHAV} \quad \text{(scaled B6)}$$

$$TS = TS - \left(P_2' + \frac{K_{j3j2\_X2}}{\text{ALPHAM}}\left(P_3' + \frac{K_{j4j3\_X2}}{\text{ALPHAM}} P_4'\right)\right) UZ$$

$$TS = \frac{K_{j2\_X2}}{\text{ALPHAM}^4} TS \quad \text{computed quasi-floating point}$$

Reset overflow indicator

TS = FV + TS

If overflow indicator set, proceed to "GOBAQUE"

FV = TS

If bit 12(MOONFLAG) of FLAGWRDO = 0, proceed to "NBRANCH"

$$TS_1 = 5(\text{URPV}_y^{\ 2} - \text{URPV}_x^{\ 2})\ \text{ALPHAV} + 2\ \text{URPV}_x\ UX + 2\ \text{URPV}_y\ (UX * UZ) \quad \text{(in PD 2D, scaled B3)}$$

$$TS = 5\ \text{URPV}_x\ (1 - 7\ \text{COSPHI}^2)\ \text{ALPHAV} + (5\ \text{COSPHI}^2 - 1)\ UX + (10\ \text{URPV}_x\ \text{URPV}_z)\ UZ \quad \text{(in PD 8D, scaled B5)}$$

$$TS_2 = (C_{e32c31rm} / \text{ALPHAM})\ TS + C_{e3j22r2m}\ TS_1$$

$$TS = (TS_2) / \text{ALPHAM}^4 + FV$$

If overflow indicator set, proceed to "GOBAQUE"

FV = TS

X2 = PBODY

Proceed to "NBRANCH"

NBRANCH

If DIFEQCNT = -24, proceed to "DIFEQ+2"

If DIFEQCNT = 0:

PHI$\underline{V}$ = F$\underline{V}$

If DIFEQCNT = -12:

PSI$\underline{V}$ = PHI$\underline{V}$ + 4 F$\underline{V}$

PHI$\underline{V}$ = PHI$\underline{V}$ + 2 F$\underline{V}$

H = H + DTd2

DIFEQCNT = DIFEQCNT - 12

ALPHA$\underline{V}$ = Y$\underline{V}$ + H (Z$\underline{V}$ + $\frac{1}{2}$ H F$\underline{V}$)

If bit 14(JSWITCH) of FLAGWRDO = 1, proceed to "DOW.."

TS = DTd2, shifted right 9 places ($\frac{1}{2}$ interval least increment 1 cs)

If DIFEQCNT = -24:

Round TS to double precision (otherwise, a truncated shift)

TAUORB = T_c + TS

$T_{et} = T_{et}$ + TS

Perform "KEPPREP"

Proceed to "ACCOMP"

<u>KEPPREP</u> (Entered from "ALOADED", "GOBAQUE", and "NBRANCH")

KEPRTN = Return address (to routine entering "KEPPREP")

X2 = PBODY

$A_5 = \frac{1}{2}$ unitRC$\underline{V}$ · VC$\underline{V}$

QARG = (TAUORB - T_c)/|RC$\underline{V}$|

$$TS = (1/6)\ QARG^2\ (K_{muer_{-X2}} - |VC\underline{V}|^2\ |RC\underline{V}|\ )/|RC\underline{V}|$$

$$XKEPNEW = XKEP + \sqrt{K_{muer_{-X2}}}\ QARG\ (1 - A_5\ QARG + 2(A_5\ QARG)^2 + TS)$$

(XKEP also has notation "XPREV")

X1 = -10

If bit 12(MOONFLAG) of FLAGWRDO = 0, X1 = -2

Proceed to "KEPLERN" (with overflow indicator reset just before adding the "1" factor to other terms)

DIFEQ+2

$\underline{YV} = \underline{YV} + H(\underline{ZV} + \underline{PHIV}\ H/6)$

$\underline{ZV} = \underline{ZV} + H(\underline{PSIV} + \underline{FV})/6$

If bit 14(JSWITCH) of FLAGWRD0 = 1:

$\underline{W}_{27\text{-}COLREG} = \underline{ZV}$ (shifted left 3 places, compensating for "NEXTCOL" right shift)

$T\underline{S} = \underline{YV}$ (shifted left 3 places)

If overflow indicator set:

Set bit 6(ORBWFLAG) and 1(WMATINT) of FLAGWRD3 = 0

Set bit 1(RENDWFLG) of FLAGWRD5 = 0

Set bit 5(STATEFLG) of FLAGWRD3 = 1

Perform "ALARM" (pattern 0421_8)

Proceed to "TESTLOOP"

$\underline{W}_{-COLREG} = T\underline{S}$

If COLREG $\geqslant$ 0:

$T_{decl} = T_{dec}$

Proceed to third line of "INTEGRV"

COLREG = COLREG +3

Proceed to "NEXTCOL"

If overflow indicator set, proceed to "GOBAQUE" (sensing it resets)

$TNU\underline{V} = \underline{ZV}$

$TDELTA\underline{V} = \underline{YV}$

If bit 2(MIDAVFLG) of FLAGWRD9 = 1, proceed to "CKMID2"

If bit 1(WMATINT) of FLAGWRD3 = 0, proceed to "TESTLOOP"

Set bit 13(INTGRAB) of FLGWRD10 = 1

If bit 3(CSMINTSW) of FLAGWRD3 = 1:

Perform "MOVEACSM"

Set bit 12(CMOONFLG) of FLAGWRD8 = 1

If bit 1(AVEMIDSW) of FLAGWRD9 = 0:

$\underline{R} = RC\underline{V} + TDELTA\underline{V}$ (X2 used to determine

$\underline{V} = VC\underline{V} + TNU\underline{V}$ necessary shifts)

$T_{pptm} = T_{et}$

If bit 12(MOONFLAG) of FLAGWRD0 = 0:

Set bit 12(CMOONFLG) of FLAGWRD8 = 0

If bit 3(CSMINTSW) of FLAGWRD3 = 0:

Perform "MOVEALEM"

Set bit 11(LMOONFLG) of FLAGWRD8 = 1

$\underline{R}_{other} = RC\underline{V} + TDELTA\underline{V}$ (X2 used to determine

$\underline{V}_{other} = VC\underline{V} + TNU\underline{V}$ necessary shifts)

If bit 12(MOONFLAG) of FLAGWRD0 = 0: (T_{etlm} is time tag)

Set bit 11(LMOONFLG) of FLAGWRD8 = 0

Set bit 14(JSWITCH) of FLAGWRD0 = 1

COLREG = -15

If bit 2(9DIMWMAT) of FLAGWRD3 = 1:

COLREG = -24

Proceed to "NEXTCOL"

NEXTCOL

$Y\underline{V} = \underline{W}_{-COLREG}$ (shifted right 3 places)

$Z\underline{V} = \underline{W}_{27-COLREG}$ (shifted right 3 places)

DIFEQCNT = 0

$ALPHA\underline{V} = Y\underline{V}$

H = 0

Proceed to "DOW.."

<u>DOW..</u>

$X2 = PBODY$

$BETAM = K_{muer_{-X2}}$

$\underline{TS} = \underline{VECTAB}_{-DIFEQCNT}$

$$\underline{FV} = \frac{3\ (\underline{ALPHAV} \cdot unit\underline{TS})\ unit\underline{TS}\ -\ \underline{ALPHAV}}{|\underline{TS}|^3}\ BETAM$$

If bit 13(MIDFLAG) of FLAGWRDO = 0, proceed to "NBRANCH"

$X2 = -\ PBODY$

$BETAM = K_{muer_{-X2-2}}$

$\underline{TS} = \underline{VECTAB}_{6-DIFEQCNT}$

$$\underline{TS}_1 = \frac{3\ (\underline{ALPHAV} \cdot unit\underline{TS})\ unit\underline{TS}\ -\ \underline{ALPHAV}}{|\underline{TS}|^3}\ BETAM$$

If bit 12(MOONFLAG) of FLAGWRDO = 0:

Shift $\underline{TS}_1$ right 6 places

$\underline{FV} = \underline{FV} + \underline{TS}_1$ (scale factor is ALPHA$\underline{V}$ scale minus 38)

Proceed to "NBRANCH"

Quantities in Computations

See also list of major variables and list of routines

A_5: Intermediate quantity used in "KEPPREP", scale factor B7 (earth) or B5(moon), stored in push-down list location 4D (corresponds to gamma times square root of mu).

ALPHAM: Value of magnitude of ALPHA$\underline{V}$ (before ALPHA$\underline{V}$ made a unit vector), same scaling and units.

ALPHA$\underline{V}$: Cell used for several purposes. When initially enter "ACCOMP", contains position deviation scaled B22 (earth) or B18 (moon) meters. Subsequently loaded with unit(ALPHA$\underline{V}$), scale factor B1. Is then set to unit position vector (originally BETA$\underline{V}$ information), with scaling for ALPHAM correspondingly B29 (earth) or B27 (moon), and retains this setting when "OBLATE" entered. When W matrix computations are done, is used to contain value of Y$\underline{V}$ ($\underline{W}_{-COLREG}$) information. Can also be used as internal communication cells with coordinate transformation routines.

BETAM: Value of magnitude of BETA$\underline{V}$ (before BETA$\underline{V}$ made a unit vector), same scaling and units. Also used in "DOW.." to contain K_{muer_i}, same scaling as the constant.

BETA$\underline{V}$: Vector giving vehicle position with respect to body whose acceleration effect is being computed, units meters. In "ACCOMP", initial scale factor B29 (earth) or B27 (moon). If bit 13 (MIDFLAG) of FLAGWRDO = 1, subsequently contains position vector to "secondary body", scale factor B29, and then position vector to sun, scale factor B38.

$\underline{C}_{5041m}$: See Coordinate Transformations.

$C_{e32c31rm}$: Single precision erasable memory constant, program notation "E32C31RM", scale factor B80, giving information on moon's C_{31}, containing $C_{31} \times 1.5 \times r_M^3 \times mu_m$. For a value VALC31, the fraction in the cell may be computed as VALC31 x 1.5 x $(1.73809E6)^3$ x 0.4902778E9 x 2^{-80}. This fraction should not be $\frac{1}{2}$ or more (VALC31 above about 15.5E-5) to avoid overflow when divided by normalized ALPHAM.

$C_{e3j22r2m}$: Single precision erasable memory constant, program notation "E3J22R2M", scale factor B58, giving information on moon's J_{22}, containing $J_{22} \times 3 \times r_M^2 \times mu_m$. For a value VALJ22, the fraction in the cell may be computed as VALJ22 x 3 x $(1.73809E6)^2$ x 0.4902778E9 x 2^{-58}.

COLREG: Single precision cell ("column register") used to control the indexing in "DIFEQ+2" and "NEXTCOL" for the appropriate number of elements of the W matrix, scale factor B13 (since W matrix elements double precision).

COSPHI: Argument for "OBLATE" equations, program notation "COSPHI/2", scale factor B1, stored in push-down list location 18D. It is the cosine of the angle between the unit polar vector (of earth or moon) and the position vector (earth or moon centered respectively).

$DELTA\underline{V}_{cm}$, $DELTA\underline{V}_{lm}$: "Permanent" values of TDELTA$\underline{V}$ for CSM and LM respectively, same scaling as TDELTA$\underline{V}$. Program notation DELTACSM and DELTALEM.

DIFEQCNT: Single precision cell, scale factor B14, used for program control purposes, having values 0, -12, and -24 at the beginning, middle, and end of each integration step. It is negative for convenience in using interpreter indexing orders, and it is stepped by 12 to facilitate storage of a pair of double precision vectors (in VECTA$\underline{B}_i$) during each pass.

DTd2: Value of limited time increment for orbital integration, scale factor B19, units centi-seconds (is actually $\frac{1}{2}$ the value of the net increment, e.g. beginning to middle or middle to end). It is derived in "TESTLOOP".

EGRESS: Single precision cell used to retain return address information (e.g. from "AVETOMID").

FOFQ: Function of LILQ used in "GAMCOMP", scale factor (for FOFQ/RHO) B3. Program does not actually divide by RHO, but instead computes FOFQ/RHO directly: FOFQ computation shown as given, however, to facilitate comparison with published equation information.

F$\underline{V}$: Value of disturbing acceleration (second time derivative of position deviation), scale factor B-16(earth) or B-20 (moon) in meters/cs^2. Same cell used in "DOW.." for W-matrix updating, where scale factor is 38 less than ALPHA$\underline{V}$ scale factor.

H: Value of time since beginning of integration step, scale factor B19, units centi-seconds.

IRETURN: Single precision cell used to retain return address information from the subroutine entered to use the orbital integration package (after "INTSTALL" logic has given control of the package to the routine used).

IRETURN1: Single precision cell used to retain return address information from "MIDTOAV1" and "MIDTOAV2". If "MIDTOAV1" is entered (meaning that integration to a specified time is desired) but insufficient time is available to do the integration, then the time is slipped and IRETURN1 is incremented by 1 (to return to calling address +2) for appropriate disposition by caller. If enter "MIDTOAV2", cell is not incremented.

KEPRTN: See Conic Routines.

K_{3csecs}: Constant, program notation "3CSECS", scale factor B28, units centi-seconds, used as exit tolerance from "CKMID2". Value is 3×2^{-28}, corresponding to 0.03 seconds (meaning an exit if time difference is 0-2 centi-seconds).

K_{3d4}: Constant, program notation "3/4", used in "RECTEST" to check if rectification is required. Value corresponds to 0.75, with scaling same as that of the vector with which compared. Hence for earth will rectify if TDELTAV magnitude is 0.75×2^{22} meters or more, or if TNUV magnitude 0.75×2^{3} meters/csec;for moon will rectify if TDELTAV magnitude 0.75×2^{18} meters or more, or if TNUV magnitude 0.75×2^{-1} meters/csec(or more, of course).

$K_{5p6secs}$: Constant, program notation "5.6SECS", scale factor B28, units centi-seconds. Value is 560×2^{-28}, corresponding to 5.6 seconds (to ensure that calling routine can successfully blank DSKY for 5 seconds).

K_{600sc}: Constant, program notation "600SECS", scale factor B28, units centi-seconds. Value is 60000×2^{-28}, corresponding to 600 seconds.

K_{ascale_i}: Set of single precision constants used to control performance of "GAMCOMP" as selected by the value of index. Program notation for i = 0 is "ASCALE". Values for even "i" give the difference between ALPHAM and BETAM scalings, for use in determining the proper scaling of RHO:

i	Value	ALPHAM scale	BETAM scale	
0	-7	22	29	(earth, primary)
-2	-9	18	27	(moon, primary)
-4	0	29	29	(earth, secondary)
-6	-2	27	29	(moon, secondary)
-8	-9	29	38	(earth, sun)
-10	-11	27	38	(moon, sun)

Values for odd "i" are used to determine (with RHO scaling information above) the proper scaling of FV information: B-16 for earth and B-20 for moon. These values for earth are (16 - 2 x BETAM scaling + mu scaling) and for moon are (20 - 2 x BETAM scaling + mu scaling): the "2" factor is required because $BETAM^2$ is in computations.

i	Value	2 x BETAM scale	Mu scale	
1	-6	58	36	(earth, primary)
-1	-4	54	30	(moon, primary)
-3	-12	58	30	(earth, secondary)
-5	-2	58	36	(moon, secondary)
-7	-6	76	54	(earth, sun)
-9	-2	76	54	(moon, sun)

K_{dt2mn}: Constant, program notation "DT/2MIN", scale factor B20, units centi-seconds. Value is 3×2^{-20}, corresponding to 0.03 seconds (hence "TESTLOOP" exits, since original input B28 centi-seconds, if time difference is 0-2 centi-seconds). Could also be considered a minimum for DTd2, in which case value would correspond (scale factor B19) to 0.015 seconds.

K_{dt2mx}: Constant, program notation "DT/2MAX", scale factor B20, units centi-seconds. Value is $4000E2 \times 2^{-20}$, corresponding to 4000 seconds. Could also be considered a maximum of DTd2, in which case value would correspond (scale factor B19) to 2000 seconds.

K_{j2_0} : Constant, program notation "J2REQSQ", scale factor B72, selected for index value = 0. Value is 1.75501139E21 x 2^{-72}, corresponding to 3.986032E10 x $(6.378165E6)^2$ x (1082.3E-6) x 2^{-72}, where first term is earth μ (in meters^3/cs^2), second is square of earth's radius (gravitational, in meters), and third is second harmonic of earth's potential function (note that 1.5 times it = 1.62345E-3), while 4th is scale factor.

$K_{j2_{-2}}$: Constant, program notation "J2REQSQ -2", scale factor B60, selected for index value = -2 (i.e. X2 = 2). Value is 0.3067493316E18 x 2^{-60}, corresponding to .4902778E9 x $(1.73809E6)^2$ x (0.207108E-3) x 2^{-60}, where first term is moon's μ(in meters^3/cs^2), second is square of moon's radius (in meters), and third moon's J_2 (4th scaling).

K_{j3j2_0} : Constant, program notation "2J3RE/J2", scale factor B27, selected for index value = 0. Value is -0.1355426363E5 x 2^{-27}, corresponding to -0.23E-5 x 6.378165E6 / 1082.3E-6 x 2^{-27}, where first term is third harmonic of earth's potential function, second is earth radius in meters, and 3rd is second harmonic, while fourth is scaling.

$K_{j3j2_{-2}}$: Constant, program notation "2J3RE/J2 -2", scaled B25, selected for index value = -2 (i.e. X2 = 2). Value is -176236.02 x 2^{-25} (stored value merely the integer), corresponding to (-2.1E-5)/(0.207108E-3) x 1.73809E6 x 2^{-25}, where first term is moon's J_3, second is moon's J_2, third is moon's radius in meters, and fourth is scale factor.

K_{j4j3_0} : Constant, program notation "J4REQ/J3", scale factor B26, selected for index value = 0. Value is 0.4991607391E7 x 2^{-26}, corresponding to -1.8E-6 x 6.378165E6 / -0.23E-5 x 2^{-26}, where first term is fourth harmonic of earth's potential function, second is earth radius in meters, 3rd is third harmonic, and fourth is scaling.

$K_{j4j3_{-2}}$: Constant, program notation "J4REQ/J3 -2", selected for index value = -2, value 0 (since J_4 for moon is 0).

K_{muer_0} : Constant, program notation "MUEARTH", scale factor B36, selected for index value = 0. Value is 3.986032E10 x 2^{-36}, corresponding to earth μ (in meters^3/cs^2).

$K_{muer_{-2}}$: Constant, program notation "MUEARTH -2", scale factor B30, selected for index value = -2 (e.g. X2 = 2). Value is 4.902778E8 x 2^{-30}, corresponding to moon μ (in meters^3/cs^2).

$K_{muer_{-4}}$: Constant, program notation "MUEARTH -4", scale factor B54, selected for index value = -4 (e.g. X2 = 4). Value is 1.32715445E16 x 2^{-54}, corresponding to sun μ (in meters^3/cs^2).

$K_{omegmoon}$: Constant, program notation "OMEGMOON", scale factor B-23, units radians/centi-second. Value is 2.66169947E-8 x 2^{23}, corresponding to 2.66169947E-6 rad/sec. Octal value is 2.66169948E-6.

K_{p3d}: Constant, program notation ".3D", scale factor B2, value 0.3 x 2^{-2}.

K_{rde_0}: Constant, program notation "RDE", scale factor B29, units meters (selected for index value = 0), giving distance from center of earth beyond which "OBLATE" computations are bypassed. Value is $80467.20E3 \times 2^{-29}$, corresponding to 80,467.20 km, or 50,000 statute miles (5280 feet/statute mile).

$K_{rde_{-2}}$: Constant, program notation "RDE -2" (also "RDM"), scale factor B27, units meters (selected for index value = -2), giving distance from center of moon beyond which "OBLATE" computations are bypassed. Value is $16093.44E3 \times 2^{-27}$, corresponding to 16,093.44 km, or 10,000 statute miles.

K_{recrat}: Constant, program notation "RECRATIO", scale factor B0, value 0.01.

K_{rme_0}: Constant, program notation "RME", scale factor B29, units meters (selected for index value = 0), giving distance from center of earth beyond which bit 13(MIDFLAG) of FLAGWRD0 is set to 1 in "TESTLOOP". Value is 7178165×2^{-29}, corresponding to 800 km above gravitational radius of 6378.165 km. Actual stored value (due to scaling) is 7178166 meters. See "V83CALL".

$K_{rme_{-2}}$: Constant, program notation "RME -2" (also "RMM"), scale factor B27, units meters (selected for index value = -2), giving distance from center of moon beyond which MIDFLAG is set. Value is $2538.09E3 \times 2^{-27}$, corresponding to 800 km above mean lunar radius of 1738.09 km. See "V83CALL".

$K_{rsphere}$: Constant, program notation "RSPHERE", scale factor B29, units meters, giving the value of the distance from the center of the moon below which the moon is considered the primary body (check made in "TIMESTEP"). Value is $64373.76E3 \times 2^{-29}$, corresponding to 64,373.76 km, or 40,000 statute miles. Checked also in "A-PCHK".

K_{timedt}: Constant, program notation "TIMEDELT", scale factor B28, units centi-seconds. Value is 1250×2^{-28}, corresponding to 12.5 seconds.

LIIQ: Value for argument of FOFQ, scale factor B2, stored in push-down list location 8D.

LOCCTR: See Display Interface Routines.

[MMATRIX] : See Coordinate Transformations.

MUpPp: Value of μ for the primary body left in push-down list location 26D by "RECTOUT", same scale factor as corresponding K_{muer_i} (B36 for earth, B30 for moon). Program notation "MU(P)".

$\underline{NUV}_{cm}$, $\underline{NUV}_{lm}$: "Permanent" values of $\underline{TNUV}$ for CSM and LM respectively, same scaling as $\underline{TNUV}$.

P_2', P_3', P_4', P_5': Legendre polynomial derivatives computed in "OBLATE", scale factors B6, B5, B7, and B10 respectively, stored in push-down list locations 0D, 2D, 4D, and 6D (partially) respectively.

PBODY: Single precision cell set 0 in "INTEGRV" and subsequently updated if necessary, scale factor B14. Value is 0 for earth-centered measurement and 2 for moon-centered measurement. It is used to initialize interpretive language index register X2, which is in turn used to select appropriate information for earth or moon (including the number of binary shifts required).

PHI$\underline{V}$: Storage for information used in Nystrom numerical integration, scaled (for state vector updates) B-13(earth) or B-17(moon).

PSI$\underline{V}$: Storage for information used in Nystrom numerical integration, scaled (for state vector updates) B-13(earth) or B-17(moon).

QARG: Intermediate quantity used in "KEPPREP", computed in quasi-floating point fashion, with scaling (for numerator and denominator already normalized) B0(earth) or B2 (moon). It corresponds to s divided by the square root of mu, and is stored in push-down list location 4D. Hence A_5 QARG has scale factor B7 for both earth and moon.

QPRET: Single precision cell assigned to each job in the interpretive language, which may be used to retain return address information. Cell is preloaded with proper exit address from orbital integration system of routines before transfer to "INTWAKE"; before using the orbital integration package, subroutine "INTSTALL" is performed which returns immediately to the calling routine if the orbital integration package is not already in use by another user (at a lower job priority), and otherwise retains in QPRET the return address to the routine calling "INTSTALL".

$\underline{R}_{nl}$: See General Program Control.

$\underline{R}_{other}$: Position vector of "other" vehicle (i.e. LM) transmitted on downlink, scale factor B29, units meters. Same B29 scale factor applies whether moon or earth is central body.

$\underline{R}_{rect}$: Value of position vector within orbital integration (when last rectification or equivalent function was performed), scale factor B29(earth) or B27(moon), units meters.

$\underline{R}_{rectcm}$, $\underline{R}_{rectlm}$: "Permanent" values of $\underline{R}_{rect}$ for CSM and LM respectively, same scale factor and units as $\underline{R}_{rect}$.

RC$\underline{V}$: Value of conic position vector within orbital integration routine, scale factor B29(earth) or B27(moon), units meters. Also used as communication cell with orbital integration package (when entered via "INTEGRVS") to specify the position component of the state vector to be integrated.

$RC\underline{V}_{cm}$, $RC\underline{V}_{lm}$: "Permanent" value of RC$\underline{V}$ for CSM and LM respectively, same scale factor and units as RC$\underline{V}$.

RHO: Ratio of magnitudes of ALPHA$\underline{V}$ and BETA$\underline{V}$ (before becoming unit vectors) computed in "GAMCOMP", scale factor B1, stored in push-down list location 4D.

RL$\underline{S}$: See Coordinate Transformations.

RPQ$\underline{V}$: Position of secondary body with respect to primary body, scale factor B29, units meters. If bit 15(RPQFLAG) of FLAGWRD8 = 0, this means that the vector has been loaded for current integration time; if the bit is 1, this means that the vector must be computed (bit initialized to 1 when integration package entered).

RPS$\underline{V}$: Position of sun with respect to primary body, scale factor B38, units meters. Computed in "LSPOS" (and left in push-down list location 2D) with respect to earth, and subsequently changed in "ACCOMP" to be with respect to moon if necessary.

RTX1, RTX2: Single precision values of index registers X1 and X2 loaded in "MIDTOAV2" with values at exit from integration ("RECTOUT"), used to identify nature of origin of state vector (also loaded elsewhere: see Rendezvous Computations).

T_c: Time (as of start of integration cycle) since last rectification, scale factor B28, units centi-seconds. Set 0 in "RECTIFY", and incremented in Kepler computations (see Conic Routines).

T_{ccm}, T_{clm}: "Permanent" value of T_c for CSM and LM respectively, same units and scaling.

T_{dec}: Value of "decision time", i.e. final value of time to which state vector must be integrated, scale factor B28, units centi-seconds.

T_{et}: Value of the time associated with the orbital integration routine state vector, scale factor B28, units centi-seconds. It is incremented in "NBRANCH".

T_{etcm}, T_{etlm}: "Permanent" value of T_{et} for CSM and LM state vectors respectively, same units and scaling. T_{etlm} is called "TETLEM", "TETOTHER", and "T-OTHER" in program.

T_{pptml}: See IMU Computations.

TAUORB: Time within integration cycle since last rectification (or total conic integration time required), scale factor B28, units centi-seconds. Program notation is "TAU.".

TBASE2: Single precision cell used generally for retention of time base information for restart group 2 (see 3420.5-27), for waitlist restarts. Used in "INTWAKE" to permit retention of QPRET value for restart purposes (since QPRET of job involved would be lost if a restart generated, because it generally is in VAC area as described in 3420.5-27).

TDELTA$\underline{V}$: Vector position deviation (from conic) within orbital integration package, scale factor B22(earth) or B18(moon), units meters.

TNU$\underline{V}$: Vector velocity deviation (from conic) within orbital integration package, scale factor B3(earth) or B-1(moon), units meters/centi-second.

TTOADD: Value of time increment used in "CKMID2" if MID1FLAG = 0, program notation "T-TO-ADD", scale factor B28, units centi-seconds. Normal value is the same as K_{timedt}, but it is incremented by that constant if the "CKMID2" check using $K_{5p6secs}$ fails.

URP$\underline{V}$: Vehicle position vector information used in "OBLATE" for moon-fixed coordinate information, scale factor B1, stored in 14D.

U$\underline{X}$: Lunar X-axis in reference coordinates used in "OBLATE", scale factor B1, stored in 32D.

U$\underline{Z}$: Lunar Z-axis (polar vector) in reference coordinates used in "OBLATE", scale factor B1, stored in 20D. For earth is unit$\underline{Z}$.

$\underline{V}_{nl}$: See General Program Control.

$\underline{V}_{other}$: Velocity vector of "other" vehicle (i.e. LM) transmitted on downlink, scale factor B7, units meters/centi-second. Same B7 scale factor applies whether moon or earth is central body.

$\underline{V}_{rect}$: Value of velocity vector within orbital integration (when last rectification or equivalent function was performed), scale factor B7(earth) or B5(moon), units meters/centi-second.

$\underline{V}_{rectcm}$, $\underline{V}_{rectlm}$: "Permanent" value of $\underline{V}_{rect}$ for CSM and LM respectively, same units and scaling.

VC$\underline{V}$: Value of conic velocity vector within orbital integration routine, scale factor B7(earth) or B5(moon), units meters/centi-second. Also used as communication cell with orbital integration package (when entered via "INTEGRVS") to specify the velocity component of the state vector to be integrated.

$VC\underline{V}_{cm}$, $VC\underline{V}_{lm}$: "Permanent" value of $VC\underline{V}$ for CSM and LM respectively, same scale factor and units as $VC\underline{V}$.

$VECTA\underline{B}_i$: Temporary storage for values of position vector of vehicle, loaded in "ACCOMP" and used in "DOW.." for orbital integration updating of W matrix.

$\underline{W}_i$: See Measurement Incorporation.

XKEP: Value of quantity used in previous cycle through Kepler's equation (program notation also "XPREV"), scale factor B17(earth) or B16 (moon). Set 0 e.g. in "RECTIFY". Units are $\sqrt{\text{meters}}$.

$XKEP_{cm}$, $XKEP_{lm}$: "Permanent" value of XKEP for CSM and LM respectively, same scaling.

XKEPNEW: "New" value of XKEP computed in "KEPPREP", scale factor B17 (earth) or B16(moon).

$Y\underline{V}$: Communication cell with integration routines, set to $TDELTA\underline{V}$ in "INTGRATE" and also used for W matrix updating.

$Z\underline{V}$: Communication cell with integration routines, set to $TNU\underline{V}$ in "INTGRATE" and also used for W matrix updating.